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An Estimation of the Economic Value of Water Used for Irrigation in Eastern South Dakota

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AN ESTIMATION OF THE ECONOMIC VALUE

OF WATER USED FOR IRRIGATION IN

EASTERN SOUTH DAKOTA

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AN ESTIMATION OF THE ECONOMIC VALUE OF WATER USED FOR IRRIGATION IN EASTERN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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CHAPTER I

INTRODUCTION

Periodic drought in eastern South Dakota is a climatic condition nearly impossible to predict. For South Dakota's agriculturally based economy, it is a natural risk which threatens the aggregate level of business in all sectors of the economy. Undependable and untimely levels of precipitation depress not only farmers' levels of production and incomes, but the levels of all other businesses that depend directly and indirectly on agriculture for their livelihoods. The entire economy of South Dakota suffers along with the individual producers during a drought. Solutions to the problem of periodic drought are of prime importance for the stability of income levels in South Dakota.

One partial solution to the problems that arise from periodic drought in South Dakota is a shift away from dryland farming to irrigation of arable land. Irrigation allows the producer to apply water to his crops during stages of the growth and maturation process when the need for moisture is critical. Due to such factors as large ground water supplies in many portions of eastern South Dakota, soil characteristics conducive to irrigation, and the desire by producers for stability of income, a movement toward more extensive use of irrigation systems is evident in eastern South Dakota. Since 1970, irrigation in the Big Sioux River Basin has grown from near 8,000 acres to over 26,000 acres irrigated in 1976. During that same time period, the number of acres being irrigated in the Vermillion River Basin has increased from near 5,100 acres in 1970 to over 11,500 acres in 1976 (data provided by the South

Dakota Department of Natural Resource Development). Due to the increased number of irrigation systems presently in use, the demand for water has increased substantially.

Historically, water has been used as a free good; an abundant, replenishable resource with no price attached to it. In economic terms, supply has exceeded demand at all positive prices. That situation is becoming less prevalent as time passes. The demand for water is increasing due to natural population growth, industrial expansion, and increased irrigation usage. At the same time, pollution of our nation's waters by numerous sources is decreasing the supply of clean, pure water available for domestic, industrial, and agricultural consumption.

In the usual case scarce resources are assigned a price through the functioning of the private market and free enterprise system. However, water is a common property resource, with rights to its use assigned by governmental policy. The free market system is therefore unable to assign a price to it. Without a specific price it is difficult to determine the optimum allocation of water among its many competing uses.

For a number of reasons it is necessary to be able to estimate a value for water used in irrigation. An important goal of efficient allocation of water in its alternative uses is to maximize long run social benefits. This objective can be achieved only if water can be assigned a value in each of those uses. Once such a value is estimated for water used in irrigation, it can be compared to similar values for other uses. Through this comparison, improved allocation can be accomplished. Given estimates of water value, policy makers will have at their disposal many of the tools necessary to establish water pricing and preference systems.

The individual producer can also use estimates of water value. Should the legislature of South Dakota decide on a comprehensive state water policy that includes a system of water pricing policies, the producer can then use an estimated value of water for agricultural production as a limit on the price which it would be profitable for him to pay to use water in irrigation. Estimates of the value of water for various crops or crop rotation patterns may also provide guidelines for agricultural producers concerning what crops could profitably be irrigated under various water pricing policies.

Another justification for this project concerns the content of previous studies that attempted to estimate values for water in alternative uses, especially irrigation. The majority of studies done in the past concerning the productivity of water have used data simulated by engineering formulas. Such simulations often assumed that the producer used all of his productive inputs with perfect efficiency. In reality that is seldom the case. Through the use of budgets and primary data concerning the utilization levels of various inputs into the production process, resulting data can be compared to check the simulated data for its realism.

The gist of the problem is that there is a need for analysis of primary data concerning the economic value of water in irrigation. That type of information is necessary to provide a realistic guideline for policy makers who need estimates of the value of water in alternative uses to formulate water allocation regulations and for producers who need estimates to examine the profitability of irrigating various crops in the face of possible incremental increases in the price of water.

Objectives

The general objective of this study was to estimate an economic value for water used for irrigation in the Big Sioux and Vermillion River Basins of eastern South Dakota. The accomplishment of the following specific goals led to the achievement of the primary objective:

1. to derive irrigated crop production budgets from primary data for each river basin,

2. to develop net returns for 1977 per irrigated composite acre net in each river basin,

3. to develop dryland composite acre net returns for 1977,

4. to develop and compare dryland and irrigated crop production budgets and composite acre net returns for the period 1970-1977, and

5. to obtain an estimate of water's value in agricultural production.

Description of the Study Area

The Big Sioux and Vermillion River Basins drain an area covering most of the two eastern tiers of counties in South Dakota (see Figure 1). The Big Sioux River starts in northeastern South Dakota in the southwestern tip of Roberts County. The river drains most of the counties along the eastern border of the State as well as several counties in southwestern Minnesota and northeastern Iowa. The central portion of this basin formed the northern rainfall region discussed in this study.

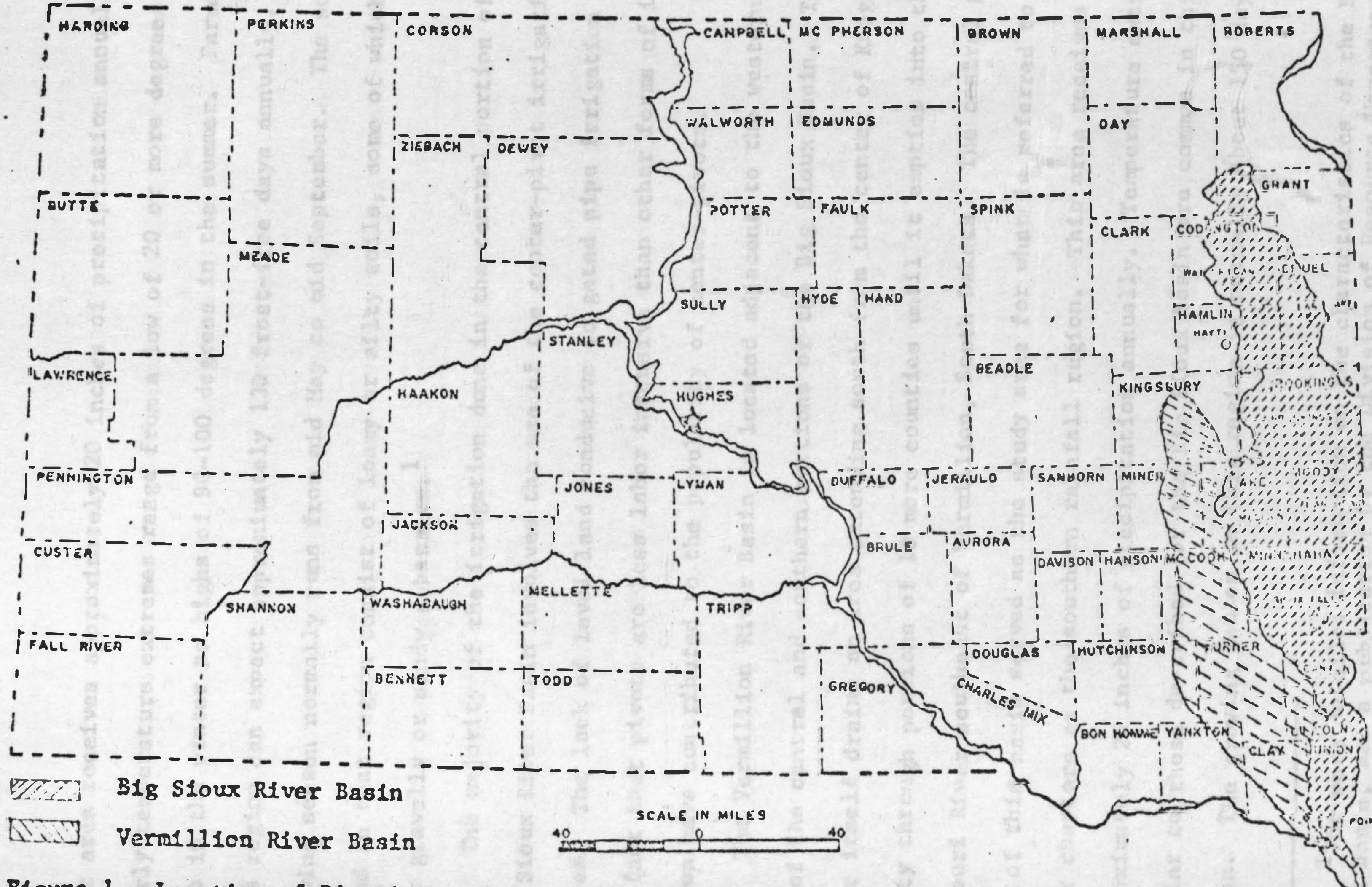

Figure 1. Location of Big Sioux and Vermillion River Basins in eastern South Dakota.

Sources: Resource Inventory of The Big Sioux River Basin by Division of Resources Management and Resource Inventory of the Vermillion River Basin by Thomas W. Lowe.

That area receives approximately 20 inches of precipitation annually. Yearly temperature extremes range from a low of 20 or more degrees below zero in the winter to highs of 90-100 degrees in the summer. Farmers in this region can expect approximately 130 frost-free days annually. The growing season normally runs from mid May to mid September. The soils found in that region consist of loamy or silty soils, some of which lie over gravelly or sandy substrata.[1]

The majority of the irrigation done in the central portion of the Big Sioux River Basin involves the use of the center-pivot irrigation system. The lack of level land conducive to gated pipe irrigation and the fact that pivots are less labor intensive than other forms of irrigation have contributed to the popularity of center-pivots.

The Vermillion River Basin is located adjacent to the western border of the central and southern portions of the Big Sioux Basin. The river itself drains an area extending south from the center of Kingsbury County through portions of 10 more counties until it empties into the Missouri River southeast of Vermillion, South Dakota. The central portion of this basin served as the study area for what is referred to in later chapters as the southern rainfall region. This area receives approximately 24 inches of precipitation annually. Temperature extremes similar to those described for the Big Sioux Basin are common in this region. The growing season in this region is normally about 150 days

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[1]For more detailed information on the characteristics of the Big Sioux Basin, see a publication by the Division of Resource Management of South Dakota, June, 1972.

long, running from the first week of May to approximately the first week of October. Upland soils found in the region consist mainly of loamy or silty soils, whereas alluvial or clayey-loam soils lying over gravelly or sandy substrata are prevalent in low lying areas.[2]

Irrigation in this region again primarily is done using center-pivots. The reasons for their popularity are the same as those discussed for the Big Sioux Basin. Irrigation is an older, more familiar farming practice in this area compared to the northern rainfall region.

The next chapter contains a review of past research efforts that were aimed at estimating values of water in alternative uses. The methods used in and the results obtained from those studies is presented.

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[2] For more detailed information concerning characteristics of the Vermillion River Basin, see a publication by Thomas Lowe, April, 1977.

CHAPTER II

REVIEW OF LITERATURE

Several studies dealing with the valuation of water in alternative uses are analyzed in this chapter. A thorough investigation of their objectives, methodology, and conclusions lays the ground work for the methodology and procedures discussed in later chapters.

Estimation of the Value of Water in Irrigation

The first group of works considered focuses on the determination of water's value in agriculture. Various procedures and techniques have been used to estimate the value of water in irrigation. Renshaw (1957 and 1958) proposed a theory suggesting that land markets tend to capitalize a portion of net farm income into land values. In attempting to support that contention, he developed linear regression models. While the results of Renshaw's models supported his hypothesis in most cases, the overriding importance of his work may be that he laid the groundwork for later studies.

Hartman and Anderson (1962) extended Renshaw's work by attempting to estimate the value of water in Northeastern Colorado through the use of multiple regression techniques. The hypothesis underlying this approach was that irrigation project benefits may be reflected in land values through land purchasers' and sellers' estimates of the capitalized value of future income flows.

The equation which proved to be most useful to the researchers regressed the observed selling prices of farms for the years 1954-1960 on the assessed value of buildings, total acres of farmland, and shares of irrigation company stock for that same time period. The model generated regression coefficients which represented estimates of yearly water share values. Those estimates were compared with actual market values of water stock traded by the North Poudre Irrigation Company. It was found that the estimates given by the model corresponded quite well with actual market prices per share. Regression estimates ranged from $105 in 1954-1956 to $198 in 1960 while quoted market prices ranged from $70 in the early 1950's to approximately $200 in 1962. By dividing the regression estimates by the amount of water delivered (in acre-feet) by the irrigation project, the capitalized value of water shares per acre-foot are $31.82 for 1954-1956 and $30.94 for 1960.

Milliam (1959) discussed some of the implications involved with Renshaw's technique of using changes in agricultural land values as indirect measures of the primary benefits derived from irrigation development. Renshaw claimed that the method of analyzing changes in land values involves fewer assumptions than budgeting and reduces the possibility of overcounting of costs and returns. Milliam, on the other hand, felt that the land value approach assumed that land was the only fixed factor involved in the production process. Increases in land values could have understated the economic value of water if some portion of that value were capitalized into certain equipment involved with the purchase and use of irrigation water. Milliam also raised the point that surplus value arising from the use of irrigation water by a farmer will only be capitalized in land values if the land (or land owner) had a permanent claim to the water. If the irrigation company supplying the water could deny the use of that water to the irrigator at its discretion, it is doubtful that the water's value would be capitalized into land values.

Milliam also compared the advantages and drawbacks of the land value technique with those associated with the widely used budgeting method of arriving at the value of water in irrigation. Milliam explained that the major objection to the use of the budgeting method for estimating the value of water is the inherent necessity of making assumptions concerning future yields, costs, receipts, and production coefficients if predictions of water's value are to be made.

The final argument raised by Milliam against the use of land values as indicators of water's value was that the excess production, or surplus value, of crops arising from the addition of irrigation water may be due to increases in other inputs such as fertilizer or other chemicals as well as water. In this case, it could be argued that increases in land values overstate the value of water in irrigation.

Ruttan (1965) used least-squares procedures to estimate production functions for irrigated farms in various regions. He developed Cobb-Douglas type production functions from which the marginal value productivities (MVPs) of irrigated land and operating expenses were derived. By subtracting Ruttan's estimated MVP for non-irrigated land from that of irrigated land and dividing by the amount of water applied (1.1 acre-feet per acre) an estimate of about $65 per acre-foot was obtained for the Upper Arkansas-White-Red River subregion.

Close examination of Ruttan's approach by other scholars led to several suggested modifications of his technique. Hoch (1967) and Beattie (1971) asserted that Ruttan had omitted several relevant variables in the final version of his model. In actuality, Ruttan presented only irrigated land and current operating expenses as factors in his final model while omitting all farm workers, machinery investment, livestock investment, and non-irrigated cropland. Due to this misspecification error an upward bias in Ruttan's marginal value product coefficients was created.

Beattie also was critical of Ruttan's use of county data in estimating the production functions from which the MVPs were derived. In the water resource regions for which Ruttan estimated production functions, Beattie asserted that counties were not homogeneous observational units. He pointed out that in many western states, counties are large and varied in their agricultural composition. Wide variations in soil type and crop rotation patterns could have reduced the reliability of his MVP estimates.

Beattie's attempts to improve Ruttan's model involved the inclusion of more variables in the final model and the choice of a more homogeneous study area, namely the Texas and Eastern New Mexico High Plains. His empirical estimate of MVP for irrigation water on cotton was \$33.32 per acre-foot. The estimated MVP for non-cotton crops, primarily grain sorghum and wheat was \$20.29 per acre-foot.

In a paper prepared by the Bureau of Agricultural Economics at Berkeley, several principles governing the valuation of water in irrigation were proposed. In the article, the value of water was defined as "the total net increase in income due to irrigation, in excess of the income which could be obtained from the next best use of the land, labor, capital, and managerial ability that is employed." (Bureau of Agricultural Economics, Berkeley, 1943, p. 1). Even though the authors realized that there will be a large degree of arbitrariness in determining a value for water in irrigation, they accepted budgeting as the most suitable and effective instrument for calculating the net increases in monetary income due to irrigation.

Budgeting as a Method of Developing Costs and Returns for Crop Enterprises

History has shown that budgeting has long been accepted as an appropriate method for determining costs and returns for irrigated and dryland crop production. Since budgeting is of fundamental importance to this study, consideration of previous works involved with this technique was deemed necessary.

Grubb (1966) used composite acre crop production budgets to determine returns to irrigation water and farm management in the High Plains of Texas. His study method involved the subtraction of irrigated output production costs from gross revenue obtained from the sale of that output to derive the primary benefits of irrigation.

Grubb's composite irrigated acre concept can be defined as the representative or average irrigated acre of land in a given area at a particular point in time. The composite acre represents the relative percentage of total cropland which each major crop occupies in an area.

As an example, Grubb's composite irrigated acre for the North Texas High Plains contained 32% cotton, 38% grain sorghum, and 21% wheat. The end result of Grubb's effort was that the maximum amount per composite acre farmers could pay for irrigation water was $28.74. At that price, farmers would be receiving no direct return to water and management.

Carkner and Schaffner (1974) also used the composite acre and budgeting techniques to develop data necessary for an investigation of the economic impacts of irrigation in the south-central region of North Dakota. Through examination of the composite acre expenses and returns presented in budget form, irrigation showed a net return to water and management of approximately $30.00 per composite acre.

Research at South Dakota State University

Numerous studies have been conducted by personnel in the Economics Department at South Dakota State University dealing with various facets of irrigation development in South Dakota. Most have dealt with analysis of economic impacts of potential irrigation development rather than developing the data necessary for proper allocation of declining water supplies among competing uses.

Helfinstine (1964) researched the possible economics of irrigation development in the north central region of South Dakota bordering the Oahe Reservoir. He used a budgeting technique to examine the profitability of various irrigated and dryland crop and livestock enterprise combinations for different size farms. Helfinstine pointed out that possibly the most important factor favoring irrigation involves the stabilization of farm income over production periods.

An investigation into the effects of potential irrigation development in Brookings County, South Dakota was performed by Matson and Fischer (1969). They used a linear programming model to examine the economic feasibility of sprinkler irrigation development in Brookings County. The LP model determined the optimum organization of crop and livestock enterprises on farms of three different sizes assuming high and low percentages of cropland acres on each farm size. In the study, it was found that returns to family labor and management could be increased by inclusion of irrigation into the farmers' cropping plans. Although part of this added return should be attributed to water, the crucial finding of this study was that net farm income could be increased by irrigation.

Expenditure and income data generated in the optimal farm plan chosen were then used to estimate area impacts of irrigation development. The results of the regression analysis used to accomplish this objective showed that the economic impacts from irrigation on incomes accruing to nonfarm sectors in the area were almost equal to the direct changes in farm incomes. This would suggest that the multiplier effect of increased farm expenditure would be near unity.

Wolff (1970) also used linear programming in an attempt to determine optimal enterprise combinations and farm organization required to maximize profits from the adoption of irrigation in the Eastern Missouri slope area of South Dakota. He also examined how the optimal combination of enterprises would vary between tow-line, center pivot, and wheel move irrigation systems.

As in the Matson and Fischer publication, crop and livestock production budgets were used as inputs into the linear programming format. Under the assumption that unrestricted amounts of capital and labor were available to the farmers, irrigation increased returns to farm management by as much as 149 percent over similar 320 acre dryland farms. Similarly, at the 640 acre level returns to management increased as much as 264 percent over dryland. At the 960 acre level, 376 percent was shown to be the maximum increase in returns over dryland. A large share of those increases was due to increases in livestock production as more acres were irrigated. When restrictions were placed on the amount of livestock which could be purchased, operating capital and labor requirements were lessened, making the program's solutions somewhat more realistic.

A study closely related to Wolff's was done by Graham (1972). His primary objective was to revise two critical assumptions of Wolff's linear programming model so that it would more closely represent the real-world situation. Wolff assumed that any amount of labor required for the farming enterprise above that which could be supplied by the operator and his family could be hired at $2 per hour. Graham assumed that one full-time hired man (3224 hrs. per year) was available along with a maximum of approximately 900 hrs. per year additional hired labor at $2.00 per hour. In addition, Graham also restricted the amount of operating capital available to the farmer by tying it to the amount of equity the farmer held in the assets of the farm.

At the end of the study, several recommendations to current and prospective irrigators were made pertaining to the most desirable crop and livestock enterprise mixes. He stated that in the case of a farm firm facing restricted labor supplies, irrigation should be applied in support of cash crop or pasture based livestock enterprises. In the alternative case of capital restrictions, the conclusion was that irrigation should be used in the production of feed grains in support of a higher return cattle feeding operation. In general, Graham found labor to be the restricting factor more often than capital.

Estimations of the Value of Water in Alternative Uses

These studies suggest that past research dealing with irrigation have been concerned primarily with estimating the primary and secondary impacts of projected expansion of irrigation. This was due in part to the fact that in years past few people were concerned with the availability of quality supplies of water. Little interest was shown in the area of developing a demand function for water in alternative uses. This is no longer the case. Present demand for water from the municipal, domestic, industrial, and agricultural sectors is on the upswing. Use of water for hydropower and recreation is also increasing at a rapid rate. Water may no longer be available in unlimited quantities and may have to be allocated to these competing uses.

Regan (1958) addressed the problem of competition among alternative uses and values of water. He noted that uses such as recreation, hydropower, and navigation are generally considered to be nonconsumptive in that they don't actually deplete the supply of water. Irrigation, however, is a highly consumptive use. Regan emphasized that water's net value in any use depends not only on its productivity in alternative uses, but also on the cost of developing water resources. Hence he found that the allocation and valuation of water were essential components in the process of formulating a comprehensive water-resources development program. In order for such a plan to be developed, a complete data base concerning values of water in alternative uses is necessary. The following discussion centers around the value of water in the industrial, municipal and domestic sectors.

De Rooy (1974) examined the price responsiveness of the demand for water by industrial firms. Using a logarithmic form mixed regression technique he estimated price elasticity of demand coefficients for water used for cooling, processing, and steam generation. The coefficients derived, especially those which corresponded to water used for cooling, demonstrated that the demand for water by industry was not totally price inelastic, as had been previously believed by many economists. The estimated elasticity coefficients approached unity rather than zero.

Berry and Bonom (1974) hypothesized that per capita water use in municipalities was directly related to per capita income, population of the city, and aridity but inversely related to water rates. The testing of these hypotheses involved the use of regression analysis. Their results indicated clearly that income was the major determinant of per-capita municipal water use. The authors realized that other unspecified variables, such as water requirements for municipal parks and golf courses, could also be important as determinants of municipal water demand. They emphasized too, that the climatological variable could be a significant explanatory variable in interregional municipal water demand studies.

Howe and Linaweaver (1967) examined the effect that price has on the quantity of water demanded by residences for household and indoor purposes as well as for outdoor uses, primarily sprinkling. Regression analysis was used to estimate demand functions for indoor and outdoor uses. Their major findings were that domestic (indoor) demand is relatively price inelastic and that sprinkling (outdoor) demand is price elastic, but more so in the Western States than in the East where the climate is less arid.

Platek (1978) attempted to derive an average household's demand function for water within the Big Sioux River Basin of South Dakota. Platek's hypothesized demand equations represented the quantity of water demanded per household as a function of the price of water, average number of persons per household, average annual income per household, and average monthly rainfall deficiency. Using least squares multiple regression analysis on linear and logarithmic forms of the demand functions, the author found the price of water and income to be significant variables and that the consumption of water was dependent more upon income of households than on the price of water.

Finally, Young and Gray (1972) presented a conceptual framework for establishing values for water usable in water allocation and development decisions. As a part of their study they discussed alternative approaches for assigning values to water in the absence of a market value.

The first of these approaches was that of actual observation of transactions relating to water. Some examples of this are transactions in a water rental market, transfers of water rights, and the sale of water through an administered price system where a public agency or utility may sell water through a metered system.

The second approach they discussed was that of deriving a demand function for water. From the demand function marginal value products could be estimated. The difficulty of this approach was that water had seldom been included as an input in agricultural production functions. This may change in the future, making this a more readily applicable tool.

Young and Gray also presented a concept called alternative cost as a measure of the value of water. The essential idea in this method was that the value of water in a project should be equal to the cost of providing the water through the project.

Young and Gray's third method of valuing water was that of residual imputation as a method of resource valuation. They defined residual imputation as a procedure which allocates the total value of output to each of the resources used in the production process. Since residual imputation was used in this study, the theory and assumptions of this method are examined in the following chapter.

CHAPTER III

THEORY AND PROCEDURE

Theory

The primary objective of this study was to estimate an economic value for water used for irrigated crop production. In order to accomplish this, irrigated crop production budgets were derived from information obtained from irrigators. Net returns per acre, or the residual remaining when total costs per acre are subtracted from per acre total revenue, were determined. That residual represented an estimate of a value for labor, management, and water in irrigated crop production. Labor and management charges were then deducted in order to estimate a value for water alone.

Within the field of the economics of agricultural production, there are two interrelated theories of primary importance when attempting to estimate a value for the aforementioned residual attributable to water. Euler's Theorem and the concept of residual imputation comprise the portion of microeconomic theory on which the estimation of values for labor, management, and water are based. Robinson (1934), Barret (1974), and Henderson and Quandt (1971) presented good illustrations of the concept of Euler's Theorem, but Heady (1952) presented perhaps the best discussion of Euler's Theorem and residual imputation as they relate to resource valuation.

In general terms, Euler's Theorem can be represented mathematically as follows:

Eq. 1: $X_1 f_1 + X_2 f_2 + \ldots + X_n f_n = kg(X_1, X_2, \ldots, X_n)$

Where:

X_i = quantity used of input X_i

f_i = marginal productivity of X_i

k = degree of homogeneity

The degree of homogeneity of a production function refers to the effect that increasing the level of inputs has on total output. If a production function is homogenous of degree one, $k = 1$, the function is said to exhibit constant returns to scale. In this case, if all inputs were doubled in quantity used, total output would also be doubled. If a production function exhibited increasing returns to scale, $k > 1$, output would be more than doubled if inputs were doubled. Similarly in the case of decreasing returns to scale where $k < 1$, doubling of all inputs would less than double output.

The adaptation of Euler's Theorem was extended for this study by including price coefficients with the input and output quantities as follows:

Eq. 2: $PQ = P_{X_1} X_1 + P_{X_2} X_2 + \ldots + P_{X_n} X_n$

Where:

P = price of output Q

Q = Total Output

P_{X_i} = price of input X_i

Leftwich (1973) assumed that producers of agricultural products attempt to maximize their profits. Furthermore, Leftwich (p. 306) stated that "the profit maximizing level of employment of A (a resource) by the firm is that level at which the value of the marginal product of A is equal to the price per unit of the resource." This profit maximizing condition can be written as follows:

Eq. 3: $VMP_a = P_a$

or (Leftwich, p. 307)

$MPP_a \times P_x = P_a$

where subscript a refers to the resource and subscript x refers to output.

Since in effect it has been stated that;

Eq. 4: $VMP_{X_1} = P_{X_1} f_{X_1} = P$

where:

VMP_{X_1} = value of the marginal product of X_1

P_{X_1} = price per unit of input X_1

f_{X_1} = marginal productivity of input X_1

P = price of the output

it can be further stated that;

Eq. 5: $VTP = PQ = VMP_{X_1}X_1 + VMP_{X_2}X_2 + \ldots + VMP_{X_n}X_n$

In this project, $X_1, X_2, \ldots X_{n-1}$ represented irrigated crop production inputs such as fuel, fertilizer, herbicide, insecticide, etc., and VMPs equalled the factors' respective prices. The residual, $P_nX_n = VMP_nX_n$, represented the return to labor, management, and water.

Equation 2 states that total output would be completely distributed to each factor of production in accordance with the value of its marginal productivity. In order for this assumption of Euler's Theorem and residual imputation to be met, the production function must be homogenous of degree one. If a production function was homogenous of a degree other than one, that is to say it exhibited increasing or decreasing returns to scale, the change in output when all inputs were increased (or decreased) proportionally would be non-proportional. To more clearly illustrate this point, Euler's theorem can be represented mathematically as follows:

$$\text{Eq. 6:} \quad PQ = \frac{1}{k} \sum_{i=1}^{n} VMP_{x_i} X_i$$

From the above function, which is homogenous of degree k, it can be shown that if $k = 1$, we have constant returns to scale, hence the value of total output = PQ would just be completely exhausted. If k were greater than one, the production function would exhibit increasing returns to scale. If, in this case, the factors were paid the value of their marginal products, those factor payments would exceed the value of the output. Similar reasoning in the case of decreasing returns to scale would show that factor payments would be less than the value of the output.

The application of the previously discussed theory is presented in the next section of Chapter III. Procedures and methods used in the estimation process are discussed.

Procedure

Introduction

The methods used in this study were aimed at estimating a value for water in irrigation. That value of water was assumed to be equal to the "total net increase in income due to irrigation, in excess of the income which could be obtained from the next best use of the land, labor, capital, and managerial ability that is employed" (Bureau of Agricultural Economics, 1943, p. 1). It was further assumed that the next best alternative for employment of the non-water resources was dryland farming.

Based on those assumptions, the following methods were used to estimate a value of water in the Big Sioux and Vermillion River Basins of South Dakota. Since budgeting was chosen as the primary tool to be used in the estimation process, it was necessary to develop both irrigated and dryland crop production budgets within the two river basins. The procedures used in deriving irrigated crop production budgets are discussed in the following section. The methods used to obtain the dryland budgets will be discussed in a later section.

Derivation of Annual per acre Irrigated Crop Budgets

The first step necessary in estimating a value for water in irrigation was the derivation of irrigated crop production budgets. The primary budget data used for the derivation were gathered through personal interviews with irrigators within the two river basins. Differing levels of rainfall and lengths of growing seasons between the two basins necessitated a separate estimate of value in each area. In order that the observational units selected within the basins be as homogenous as possible, a representative county in each basin was selected. Brookings County was chosen as a representative of the northern rainfall region, within the Big Sioux River Basin due to the large number of irrigators from which a sample could be taken. Turner County was selected for the same reason as representative of the Vermillion River Basin and the southern rainfall region.

Approximately 25 percent of the irrigators in each county were surveyed using a questionnaire designed to gather information concerning 1977 costs and returns associated with irrigated crop production. Variable cost data gathered included storage and drying, seed, fertilizer, herbicide and insecticide, crop insurance, custom hire, fuel and lubricants, system power and repair, general machinery repair, general overhead, and interest on operating capital. Fixed costs including depreciation and interest on irrigation systems, machinery and storage facilities were computed using actual farmers' investments in those assets. Data on interest on land investment and insurance on farms and irrigation systems were also gathered. Crop yield data were collected so that net returns for irrigated crops could be computed. Those percentages were used in the development of composite acre irrigated crop production budgets in each rainfall region. The questionnaire used to amass the preceding information appears in Appendix B.

Once the survey was completed, soils maps were used to categorize the land into soil type groups within each rainfall region. In Brookings County, the surveyed farms were classified into two broad soil groups. A nearly equal number of surveyed farms were contained in the sandy soil type group and in the heavier loamy soil type. A publication entitled Soil Survey, Brookings County, South Dakota (Westin, et. al., 1955) was used as the definitive source for the soil type breakdown.

A similar procedure was used for classifying Turner County survey participants. As in Brookings County, two major soil classifications were found in Turner County, silty soils and heavier clayey-loam soils located over a gravelly substrata. A General Soil Map for Turner County (unpublished preliminary map, 1979) was used.

Crop production budgets were then derived for each survey respondent using the data collected. The budget form developed for that purpose appears in Appendix B.

Many of the variable costs associated with irrigated crop production were straightforward and easily obtained directly from the irrigators. Those costs, including system power, machinery and system repairs, custom hire, seed, fertilizer, herbicide, insecticide, drying, and storage, were transferred from the questionnaire directly to the budget form. There were, however, costs incurred by the irrigators that were not so readily obtained and calculated. The following paragraphs explain the procedures used for arriving at those cost figures.

Derivation of Variable Costs

Fuel costs per acre for each irrigated crop were computed by first, listing all field operations performed on each crop from the interview process. For each of these operations, the width of the implement used and the speed traveled were used to compute the number of acres covered per hour. Since the model number of the tractor and other implements used in each field operation were obtained from the questionnaire, it was possible to estimate the number of gallons of fuel being consumed per hour in each operation through the use of estimated fuel consumption coefficients (Nebraska Tractor Test Data, pp. N31-N43, 1977). Fuel consumption (gallons per hour) was then divided by the number of acres per hour covered to compute the number of gallons of fuel being used per acre of cropland in each field operation. That figure was multiplied by the price of fuel as related by the irrigators in order to determine the once over fuel cost per acre of each field operation. This figure was divided by .75 in accordance with the assumption of 75 percent field efficiency for all operations. If field operations were performed more than once, the cost per acre figure was adjusted by the number of times over. The summation of all fuel costs per acre for each operation yielded total machinery fuel cost per acre.

In some cases, oil and other lubrication costs were not available from farmers due to the fact that oil and fuel bills are often paid for in total to one supplier of all commodities. In those cases, five percent of fuel costs per acre were used as representative lubrication costs per acre.

The inclusion of miscellaneous costs incurred by farmers, such as membership fees for farm organizations, record keeping fees, income tax consultant fees, legal fees, farm magazine subscriptions and numerous other expenses of running the farm business, involved the use of a variable cost category called overhead. Overhead costs were calculated as five percent of all variable costs excluding interest on operating capital. Interest on operating capital was calculated at a nine percent annual rate. Operating loans were assumed to be for six months in duration.

Derivation of Fixed Costs

Depreciation

Depreciation on all farm machinery, irrigation systems and storage facilities was computed using the straight line method and actual investment figures supplied by the irrigators. All storage facilities were assumed to have a useful life of 20 years and a salvage value equal to 10 percent of their original costs. Only those facilities used for storage of irrigated crops were depreciated.

Annual depreciation of farm machinery was based on the nature of its use in the overall farming operation. Farm equipment including tractors, plows, discs, etc., which is generally used on all cropland was depreciated over the total acres of dryland and irrigated cropland. Specialized machinery, like combines, corn planters, corn cultivators, swathers, balers, etc., was depreciated only over the acres of those crops with which it could be directly associated. All farm machinery was assumed to have a 10 year life and a salvage value equal to 10 percent of their original costs.

The irrigation systems were depreciated only over the acres each covered. They were assumed to have 15 year useful lives and salvage values equal to 10 percent of their original costs.

Interest

Interest on investment in storage facilities, farm machinery, and irrigation systems was computed at a rate of seven percent of average annual investment. Interest on land was calculated using a rate of six percent of current (1977) market value. Estimates of the current value of irrigated land were $1,000 per acre for the northern rainfall region and $1,200 per acre in the southern rainfall region.

Other Fixed Costs

The costs of insuring farms and irrigation systems were gathered directly through the survey as were personal property and real estate taxes incurred by the irrigators. These costs were reduced to a per acre basis by dividing them by the total number of acres of cropland farmed, both dryland and irrigated ground.

After all irrigated crop production budgets had been extracted from the survey questionnaires, the budgets for each river basin were grouped according to their respective soil types. The individual budgets were then totaled by crop and averaged for each soil type group. The average crop budgets for sandy and loamy soil types in the northern rainfall region as well as silty and clayey loam over gravel soil types for the southern rainfall region are presented in Appendix A. Those same budgets were used to calculate county average crop production budgets which appear in Chapter IV.

Deflation of 1977 Cost Figures

In order to examine net returns for the period 1970-1977, it was necessary to deflate the 1977 irrigated crop production costs gathered from the farmers. Average irrigated crop production costs were combined into four major categories to better facilitate the deflation process.

1. Total Variable Costs
2. Land Charge (interest on land investment)
3. Depreciation, Taxes and Insurance
4. Interest on Investment in Storage Facilities and All Equipment

The 1977 components of the four major costs categories for each irrigated crop were then deflated using various indexes. Land charges were deflated using indexes of average farm real estate value for the State of South Dakota (ESCS, July 1978, p. 18). The other three cost categories were deflated using indexes of prices paid by farmers (U.S.D.A., 1977, p. 461).

Total revenues for each irrigated crop, except corn silage, were then computed using average annual prices received by South Dakota farmers for the years 1970-1977 (Crop and Livestock Reporting Service, 1976 and 1979, p. 79). Because data concerning the price of corn silage were unavailable, Dr. Wallace Aanderud of the S.D.S.U. Economics Department suggested a rule of thumb which was used to estimate market price. Dr. Aanderud suggested that an estimate for corn silage price could be calculated by taking four times the market price of corn and adding to that .15 times the price of alfalfa. The crop yields used in determining total revenue were assumed to remain constant and equal to the 1977 average yields obtained from the survey. Deflated total costs for each crop were subtracted from the corresponding total revenues to obtain historical net returns for irrigated crops in each rainfall region.

Derivation of Irrigated Composite Acre Net Returns 1970-1977

The historical net returns computed in the previous step were used to develop composite acre net returns for each year. The composite acre of irrigated land represents the proportion of total cropland devoted to each major crop, such that the sum totals to 100 percent. Those proportions were estimated from the data contained in the surveys from each rainfall region. The proportions were assumed to remain constant over time. The net return for each major crop was multiplied by its corresponding proportion of total cropland to give a weighted net return. The summation of those nets yielded a net return per composite acre for both rainfall regions. The net returns per composite irrigated acre for the years 1970-1977 in each river basin are presented in Chapter IV.

Derivation of Composite Acre Dryland Budgets and Net Returns 1970-1977

The dryland crop production budgets used as the base for the determination of composite acre dryland budgets were adaptations of 1977 dryland budgets published by the S.D.S.U. Experiment Station (Derscheid, Aanderud, and Allen, 1977). This was done because it was the opinion of county agents and farmers within the rainfall regions that those budgets were relatively good representations of actual costs incurred in the production of dryland crops.

Most of the cost figures used were taken directly from the publication, however, several changes were necessary. Total cash costs given in the publications were adjusted upward by 4.5 percent to reflect a charge for interest on operating capital. Interest charged on average machinery investment was adjusted from an 8.5 percent rate to the seven percent rate used in the irrigated crop production budgets.

Real estate taxes were levied at one percent of the 1977 market value per acre of dryland farms in each rainfall region. Land value estimates used were $600 per acre in the northern rainfall region and $750 per acre in the southern. Interest on land was charged at a rate of six percent.

Crop prices used in the computation of total revenues from dryland crop production for 1970-1977 were the same as those used in the irrigated budgets. Historical crop yields used, except for corn silage, were average county yields for 1970-1977 (Crop and Livestock Reporting Service, 1976 and 1978, unpublished). Again, a rule of thumb was employed to estimate dryland corn silage yields. Dr. Aanderud suggested that for every five bushels of dryland corn yield one could expect a yield of approximately one ton of corn silage. This estimate of silage yield was multiplied by the estimated corn silage price explained previously to determine total revenue.

Average acres of all major crops planted in each county for the period 1968-1977 were used to develop the relative percentages of major crops included in the composite acre. Using these percentages, the same procedures used in the derivation of composite acre irrigated net returns were employed to derive dryland net returns.

Comparison of Net Returns for Dryland and Irrigated Composite Acres 1970-1977

The final step in the estimation of a value for water in irrigation involved yearly comparisons of the dryland and irrigated net returns to labor, management, and water per composite acre in each rainfall region. Labor charges (at historical wage rates) based on estimated labor requirements per dryland and irrigated composite acres were deducted from net returns leaving a residual representing returns to water and management. A management charge equal to 10 percent of the difference between eight year average total variable costs per irrigated composite acre and average total variable costs per dryland composite acre was deducted from the difference in net returns to management and water. That final residual represented an estimate of an average value for water in irrigation in the northern and southern rainfall regions.

CHAPTER IV

RESULTS

Introduction

The primary results of this study consisted of irrigated crop production budgets developed from primary data accumulated by personal interviews with irrigators in the Big Sioux and Vermillion River Basins. Those budgets and dryland budgets adapted from fact sheets published by the South Dakota State University Cooperative Extension Service (Derscheid, Aanderud, and Allen, February, 1978) provided the basis for estimating composite acre net returns to labor, management, and (in the case of irrigation) water.

Comparison of Costs and Yields of Individual Crops Between Rainfall Regions

Corn

Many of the variable costs of producing irrigated corn in both rainfall regions were quite similar. There were however, some noteworthy cost differences as shown by comparing Tables 4.1 and 4.2. Seed corn costs averaged \$14.50 per acre in the southern region in comparison with \$11.50 per acre in the northern rainfall region. At the same time, fertilizer costs incurred by irrigated corn growers in the south averaged over \$52.00 per acre while comparable costs for northern corn producers equalled \$38.60 per acre. The heavier planting and fertilization rates used in the southern region, as evidenced by the costs shown in Tables 4.1 and 4.2, were reflected in the 16 bushel per acre difference in yield. The southern region's growing season is generally a few days

Table 4.1: Dryland and Irrigated Corn Enterprise Budgets for the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Dryland	Irrigated
Variable Costs		
Seed	$ 7.80	$ 11.50
Fertilizer	14.20	38.60
Chemicals	13.80	13.90
Crop Ins.	3.20	1.70
Mach. Rep.	4.60	7.10
Fuel & Lube	6.75	4.20
Drying	4.60	11.15
Storage	2.00	1.30
Overhead	3.00	5.40
Subtotal	$ 59.95	$ 94.85
System Power	---	13.10
System Repair	---	.20
Custom Hire	---	4.60
Subtotal	$ ---	$ 17.90
Int. on Op. Cap.	2.70	5.10
Total Var. Costs	$ 62.65	$117.85
Fixed Costs		
Int. on Invest.	$ 5.25	$ 18.30
Deprec., Tax, Ins.	19.70	33.80
Land Charge	36.00	60.00
Total Fixed Costs	$ 60.95	$112.10
Total Cost	$123.60	$229.95
Yield	55 bu.	129 bu.
Break-even Price	$ 2.25	$ 1.80

Table 4.2: Dryland and Irrigated Corn Enterprise Budgets for the Southern Rainfall Region for 1977

Input	Costs Per Acre Dryland	Costs Per Acre Irrigated
Variable Costs		
Seed	$ 8.95	$ 14.50
Fertilizer	18.00	52.25
Chemicals	12.50	12.15
Crop Ins.	3.50	8.55
Mach. Rep.	4.30	6.55
Fuel & Lube	6.85	4.45
Drying	6.25	5.25
Storage	2.75	---
Overhead	3.00	6.05
Subtotal	$ 66.10	$109.75
System Power	---	13.70
System Repair	---	.60
Custom Hire	---	3.20
Subtotal	$ ---	$ 17.50
Int. on Op. Cap.	3.00	5.75
Total Var. Costs	$ 69.10	$133.00
Fixed Costs		
Int. on Invest.	$ 4.80	$ 24.10
Deprec., Tax, Ins.	20.75	40.90
Land Charge	45.00	72.00
Total Fixed Costs	$ 70.55	$137.00
Total Cost	$139.65	$270.00
Yield	75 bu.	145 bu.
Break-even Price	$ 1.85	$ 1.85

longer than that of the northern region, allowing farmers to plant higher yielding, later maturing varieties of corn. Irrigated corn yields of 145 bushel per acre in the southern region, in comparison with 129 bushel per acre yields in the north, were due mainly to heavier planting and fertilization rates and length of growing season.

Another variable cost of producing irrigated corn that was found to be substantially higher in the southern region was crop insurance, or more specifically, hail insurance. Hail insurance averaged approximately $8.50 per acre in the southern region in comparison with $1.70 per acre in the northern rainfall region. This large difference in cost was primarily due to the higher risk of occurrence of hail throughout that region in comparison with the northern one.

One possible explanation for the higher drying costs incurred by irrigators in the northern rainfall region could again be climatological. Drying costs incurred by producers of irrigated corn in the north were $11.15 per acre compared to $5.25 in the southern rainfall region. Shortness of growing seasons and the probability of adverse weather conditions at harvest often forced corn producers to harvest corn earlier and wetter than was desirable. The more moisture that must be taken from corn during drying, the higher will be fuel costs associated with it.

There was one variable cost of production incurred by irrigators that may have been understated in the budgets presented in this chapter, cost of repairs for irrigation systems. They were found to be $.20 per acre in the northern rainfall region and $.60 in the south. Many of the irrigators surveyed stated that they incurred no repair costs for their irrigation systems. In most cases, that was because their irrigation systems were relatively new and still under manufacturer or dealer warranty. A more realistic long run estimate of annual system repairs would be approximately $1.00 to $1.50 per acre.[1]

Finally, it can be observed in Tables 4.1 and 4.2 that the price of corn necessary for northern rainfall region's irrigators to break-even was substantially less than that of dryland farmers in the same region. Irrigators in 1977 needed only $1.78 per bushel to cover both total fixed and variable costs, whereas dryland farmers needed to receive $2.25 per bushel. At the same time, the break-even prices of corn for both dryland and irrigated corn producers in the southern region were approximately equal to $1.85 per bushel.

Corn Silage

The variable costs incurred by irrigators and dryland farmers were quite similar to those of producers of corn for grain (see Tables 4.3 and 4.4). Machinery repair costs were greater for irrigated corn silage than for irrigated corn. This may have been because there was more wear and tear evident on specialized harvesting machinery necessary for cutting silage than on combines or corn pickers used to harvest corn for grain. Most other variable costs were lower for corn silage than for corn. Total variable costs were less for silage than for corn mainly because no in-town storage or drying costs were incurred in the

[1]This estimate was suggested by a representative of Farmer's Implement and Irrigation of Brookings, South Dakota in a personal interview conducted on March 21, 1979.

Table 4.3: Dryland and Irrigated Corn Silage Enterprise Budgets for the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Dryland	Irrigated
Variable Costs		
Seed	$ 7.80	$ 12.45
Fertilizer	14.20	42.50
Chemicals	13.80	16.00
Crop Ins.	3.20	.90
Mach. Rep.	4.60	4.00
Fuel & Lube	4.75	5.10
Drying	---	---
Storage	---	---
Overhead	2.30	4.65
Subtotal	$ 50.65	$ 85.60
System Power	---	11.30
System Repair	---	.20
Custom Hire	---	.80
Subtotal	$ ---	$ 12.30
Int. on Op. Cap.	2.00	4.40
Total Var. Costs	$ 52.65	$102.30
Fixed Costs		
Int. on Invest.	$ 6.35	$ 22.25
Deprec., Tax, Ins.	20.65	38.40
Land Charge	36.00	60.00
Total Fixed Costs	$ 63.00	$120.65
Total Cost	$115.65	$222.95
Yield	13.0 ton	20.1 ton
Break-even Price	$ 8.90	$ 11.10

Table 4.4: Dryland and Irrigated Corn Silage Enterprise Budgets for the Southern Rainfall Region for 1977

Input	Costs Per Acre	
	Dryland	Irrigated
Variable Costs		
Seed	$ 8.95	$ 13.20
Fertilizer	18.00	46.15
Chemicals	12.50	15.40
Crop Ins.	3.50	4.90
Mach. Rep.	4.30	7.40
Fuel & Lube	6.40	6.85
Drying	----	----
Storage	----	----
Overhead	2.55	5.20
Subtotal	$ 56.20	$ 99.10
System Power	----	12.10
System Repair	----	.40
Custom Hire	----	----
Subtotal	$ ----	$ 12.50
Int. on Op. Cap.	2.40	4.95
Total Var. Costs	$ 58.60	$116.55
Fixed Costs		
Int. on Invest.	$ 6.40	$ 26.75
Deprec., Tax, Ins.	24.75	50.00
Land Charge	45.00	72.00
Total Fixed Costs	$ 76.15	$148.75
Total Cost	$134.75	$265.30
Yield	13.3 ton	18.3 ton
Break-even Price	$ 10.15	$ 14.50

production of corn silage.

Fixed costs associated with the production of corn silage were greater than the same costs of producing corn for grain, mainly because of the need for specialized harvesting equipment for corn silage. Silage choppers, wagons, and blowers are often used exclusively for corn silage harvest and possibly for alfalfa hay. In contrast, combines are used for all types of grain harvest, including corn, and can often have annual depreciation and interest charges spread over more acres of land.

Yields of corn silage for the two regions were quite comparable averaging 20.1 tons per acre for the northern rainfall region and 18.3 tons per acre for the southern region. Since farmers producing corn silage in the northern rainfall region faced lower fixed costs than farmers in the southern region, their break-even price was lower, $11.10 per ton compared to $14.50 for the southern region. Differences in several of the variable costs between the regions also contributed to the higher break-even price in the southern region. Seed, fertilizer, crop insurance, machinery repair, and fuel costs were substantially higher in the southern region. Because the break-even price for dryland corn silage in each rainfall region was found to be less than that for irrigated corn silage, one could advocate dryland corn silage production over irrigated production. But, irrigation did increase per acre yields and allowed farmers to devote less acres of cropland to its production. This allowed the irrigator more flexibility in his crop rotation plans.

Alfalfa Hay

As an irrigated crop, alfalfa is similar to corn silage in that it is quite responsive to the application of additional water (see Tables 4.5 and 4.6). In the northern rainfall region irrigated alfalfa yielded 4.6 ton per acre in 1977 compared to 2.5 ton dryland. In the south, irrigated alfalfa yielded 5.9 ton and the dryland yield was 3.5 ton per acre. Irrigation in conjunction with the application of additional fertilizer, especially during the late summer growing season, often allowed the irrigator to harvest at least one more cutting of alfalfa hay than his dryland counterpart.

The increased cost of fertilizer necessary to complement additional amounts of water accounted for most of the difference in variable costs between dryland and irrigated alfalfa production. Fertilizer costs for irrigated alfalfa were calculated at $16.65 per acre in the northern region and $22.95 in the south. This compared to $7.20 and $9.60 per acre, respectively, for dryland. Per acre fertilizer cost difference between the southern and northern rainfall regions was the result of heavier fertilization rates in the southern rainfall region.

In addition to differences in land charges between dryland and irrigated cropland, differences in fixed costs were noted in interest and depreciation charges assessed against the larger investments by irrigators relative to dryland farmers in specialized harvesting machinery and storage facilities. Numerous irrigators producing high quality alfalfa hay forage have invested in relatively expensive air tight silos in order to maintain the quality of their haylage. Personal property taxes, real estate taxes, and insurance costs contributed relatively minor amounts to the difference in fixed costs.

Table 4.5: Dryland and Irrigated Alfalfa Enterprise Budgets for the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Dryland	Irrigated
Variable Costs		
Seed	$ 2.20	$ 4.50
Fertilizer	7.20	16.65
Chemicals	1.55	---
Crop Ins.	---	---
Mach. Rep.	8.40	8.30
Fuel & Lube	4.45	3.45
Drying	---	---
Storage	---	---
Overhead	3.00	2.50
Subtotal	$ 26.80	$ 35.40
System Power	---	11.70
System Repair	---	.45
Custom Hire	---	5.00
Subtotal	$ ---	$ 17.15
Int. on Op. Cap.	1.20	2.40
Total Var. Costs	$ 28.00	$ 54.95
Fixed Costs		
Int. on Invest.	$ 3.15	$ 14.25
Deprec., Tax, Ins.	12.70	33.20
Land Charge	36.00	60.00
Total Fixed Costs	$ 51.85	$107.45
Total Cost	$ 79.85	$162.40
Yield	2.5 ton	4.6 ton
Break-even Price	$ 31.95	$ 35.30

Table 4.6: Dryland and Irrigated Alfalfa Enterprise Budgets for the Southern Rainfall Region for 1977

Input	Costs Per Acre Dryland	Costs Per Acre Irrigated
Variable Costs		
Seed	$ 3.60	$ 4.10
Fertilizer	9.60	22.95
Chemicals	1.55	---
Crop Ins.	---	---
Mach. Rep.	12.55	7.45
Fuel & Lube	6.75	5.60
Drying	---	---
Storage	---	---
Overhead	3.00	2.90
Subtotal	$ 37.05	$ 43.00
System Power	---	13.35
System Repair	---	.40
Custom Hire	---	3.70
Subtotal	$ ---	$ 17.45
Int. on Op. Cap.	1.65	2.70
Total Var. Costs	$ 38.70	$ 63.15
Fixed Costs		
Int. on Invest.	$ 3.45	$ 31.60
Deprec., Tax, Ins.	17.60	57.30
Land Charge	45.00	72.00
Total Fixed Costs	$ 66.05	$160.90
Total Cost	$104.75	$224.05
Yield	3.5 ton	5.9 ton
Break-even Price	$ 29.95	$ 38.00

As in the case of corn silage, a lower breakeven price was noted for dryland alfalfa hay than for irrigated hay. Dryland break-even prices were found to be $31.95 per acre in the northern region and $29.95 per acre in the south. Irrigated break-even prices in 1977 were $35.30 in the northern rainfall region and $38.00 in the southern region. Again, application of water to alfalfa hay allowed the irrigator to devote less acres to the production of necessary forage and more to the growth of more profitable cash grains or complementary feed grains.

Soybeans

Soybeans proved to be one of the most profitable of the irrigated crop enterprises. One of the primary reasons was that irrigated soybeans do not require large additional amounts of fertilizer in comparison with dryland beans (see Tables 4.7 and 4.8). When soybeans followed corn in annual crop rotation plans, they often thrived on the small amounts of essential elements left in the soil from the previous year's crop. Additional amounts of fertilizer did not increase soybean yields by large amounts.

Once again, the increased need for larger storage capacity for the expanded volume of soybeans grown under irrigation resulted in higher interest costs and depreciation charges per acre than for dryland.

In 1977, the break-even price for dryland and irrigated soybeans grown in the southern rainfall region were nearly equal at approximately $4.40 per bushel. Irrigated beans were a more potentially profitable crop enterprise than dryland in the northern region, with a break-even price of $4.15 per bushel for irrigated and $5.10 for dryland beans.

Table 4.7: Dryland and Irrigated Soybean Enterprise Budgets for the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Dryland	Irrigated
Variable Costs		
Seed	$ 10.00	$ 9.25
Fertilizer	3.90	4.20
Chemicals	7.00	7.20
Crop Ins.	2.35	---
Mach. Rep.	3.70	5.40
Fuel & Lube	5.50	3.75
Drying	---	---
Storage	2.30	---
Overhead	3.00	2.60
Subtotal	$ 37.75	$ 32.40
System Power	---	12.60
System Repair	---	.10
Custom Hire	---	9.50
Subtotal	$ ---	$ 22.20
Int. on Op. Cap.	1.70	2.45
Total Var. Costs	$ 39.45	$ 57.05
Fixed Costs		
Int. on Invest.	$ 4.60	$ 14.80
Deprec., Tax, Ins.	17.10	25.60
Land Charge	36.00	60.00
Total Fixed Costs	$ 57.70	$100.40
Total Cost	$ 97.15	$157.45
Yield	19 bu.	38 bu.
Break-even Price	$ 5.10	$ 4.15

Table 4.8: Dryland and Irrigated Soybean Enterprise Budgets for the Southern Rainfall Region for 1977

Input	Costs Per Acre Dryland	Costs Per Acre Irrigated
Variable Costs		
Seed	$ 10.00	$ 10.40
Fertilizer	3.90	11.70
Chemicals	8.30	9.00
Crop Ins.	2.35	6.25
Mach. Rep.	3.50	7.00
Fuel & Lube	5.70	3.80
Drying	---	---
Storage	3.00	.90
Overhead	3.00	3.25
Subtotal	$ 39.75	$ 52.30
System Power	---	11.60
System Repair	---	1.00
Custom Hire	---	5.00
Subtotal	$ ---	$ 17.60
Int. on Op. Cap.	1.80	3.05
Total Var. Costs	$ 41.55	$ 72.95
Fixed Costs		
Int. on Invest.	$ 4.30	$ 20.50
Deprec., Tax, Ins.	18.35	36.35
Land Charge	45.00	72.00
Total Fixed Costs	$ 67.65	$128.85
Total Cost	$109.20	$201.80
Yield	25 bu.	46 bu.
Break-even Price	$ 4.35	$ 4.40

All Crop Budgets

As can be observed in the enterprise budgets for all crops presented in this chapter, fixed costs per acre were always higher for the southern rainfall region than comparable costs incurred by those producing in the northern rainfall region. Larger investments in capital equipment including farm machinery and storage facilities accounted for most of the differences in interest costs and depreciation charges. Real estate and personal property tax burdens were also generally higher in the southern rainfall region. This occurred because the average market value of cropland was higher in the southern rainfall region than the northern one.

Net Returns for Irrigated Corn and Alfalfa by Soil Type and Rainfall Region for 1977

In order to determine whether or not soil type had a major influence on per acre net returns for the major irrigated crops in each rainfall region, all survey respondents were soil typed through the use of regional soil survey maps (F.C. Westin, et. al., 1955 and U.S.D.A. Soil Conservation Service, unpublished preliminary map, 1979). Crop production budgets were averaged by soil type group whenever a sufficient number of budgets could be grouped into a general soil category.

In the northern rainfall region, two major groups of soil associations were evident. The first of these groups consisted of loamy or silty soils with a sandy or gravelly substrata. Soil associations represented in this group were Renshaw-Fordville, Fordville-Estelline, and Hecla sandy loam soils.

The second major group of soil associations represented loamy and silty soils without the sandy or gravelly base. These soils generally exhibited better moisture holding capacities than those with a gravelly or sandy base. Soil associations contained in this broad group included Estelline and Poinsett silty loams, Fordville, Kransburg and Vienna loams, and Lamoure alluvial soils.

Abbreviated budget forms, including information on per acre crop yields, total variable costs, total costs and net returns for corn and alfalfa in each soil type group in the northern rainfall division, are presented in tabular form (see Tables 4.9 and 4.10). Complete crop production budgets for irrigated corn and alfalfa by soil type were also computed for the northern rainfall region (see Appendix A).

As can be seen in the first column of Table 4.9, irrigated corn yields were greater on silty and loamy soils, averaging 135 bushels per acre compared to 118 bushel average on those soils with the gravelly substrata. Because of that difference in yields, net returns per acre were greater for the corn grown on soils not located over gravelly substrata. It is important to note, however, that net returns to corn enterprises grown on the sandy based soil would likely have been much lower with no irrigation because of the lack of moisture holding capacity exhibited by sandy soils. In dry years, it is not uncommon for corn yields for that type of soil to be very low, hence net returns would likely be negative.

In contrast to the corn enterprise, alfalfa yields were greater on the gravelly based soil than on soils with a less porous base. Alfalfa on the gravel based soil yielded an average 4.9 ton of hay per acre

Table 4.9: Abbreviated Irrigated Corn Enterprise Budgets Per Acre by Soil Type for Both Rainfall Regions for 1977

Northern Rainfall Region		Southern Rainfall Region	
Soil Type A		**Soil Type C**	
Yield	= 135 bu.	Yield	= 152 bu.
Total Variable Cost	= $123.05	Total Variable Cost	= $132.15
Total Cost	= $239.60	Total Cost	= $268.25
Net Return	= $7.45	Net Return	= $9.90
Soil Type B		**Soil Type D**	
Yield	= 118 bu.	Yield	= 135 bu.
Total Variable Cost	= $110.20	Total Variable Cost	= $134.00
Total Cost	= $215.00	Total Cost	= $272.10
Net Return	= $.95	Net Return	= $-25.05
All Soil Types		**All Soil Types**	
Yield	= 129 bu.	Yield	= 145 bu.
Total Variable Cost	= $118.15	Total Variable Cost	= $133.10
Total Cost	= $230.30	Total Cost	= $270.05
Net Return	= $5.75	Net Return	= $-4.70

Soil Type A: Loamy and Silty Soils - heavy base

Soil Type B: Loamy and Silty Soils - sand or gravel substrata

Soil Type C: Loamy and Silty Soils - heavy base

Soil Type D: Clayey-loam and Alluvial Soils - sand or gravel substrata

Table 4.10: Abbreviated Irrigated Alfalfa Enterprise Budgets Per Acre by Soil Type for Both Rainfall Regions for 1977

Northern Rainfall Region		Southern Rainfall Region	
Soil Type A		**Soil Type C**	
Yield	= 4.2 ton	Yield	= ---
Total Variable Cost	= $59.75	Total Variable Cost	= $ ---
Total Cost	= $163.30	Total Cost	= $ ---
Net Return	= $-7.90	Net Return	= $ ---
Soil Type B		**Soil Type D**	
Yield	= 4.9 ton	Yield	= 5.9 ton
Total Variable Cost	= $50.90	Total Variable Cost	= $65.70
Total Cost	= $162.20	Total Cost	= $218.30
Net Return	= $19.10	Net Return	= $0.00
All Soil Types		**All Soil Types**	
Yield	= 4.6 ton	Yield	= 5.9 ton
Total Variable Cost	= $55.20	Total Variable Cost	= $63.15
Total Cost	= $162.60	Total Cost	= $224.00
Net Return	= $7.60	Net Return	= $-5.70

Soil Type A: Loamy and Silty Soils - heavy base

Soil Type B: Loamy and Silty Soils - sand or gravel substrata

Soil Type C: Loamy and Silty Soils - heavy base

Soil Type D: Clayey-loam and Alluvial Soils - sand or gravel substrata compared to 4.2 ton on the heavier soil. One possible explanation for this lies in the characteristics of the alfalfa plant itself. Because corn needs large amounts of nitrogen to yield well, and the nitrogen applied to sandy or gravelly based soil tends to leach out faster than on heavier soil, corn yields were lower on sandier soil. Alfalfa, on the other hand, is a nitrogen-fixing legume, hence the leaching problem is greatly lessened. One other reason could be that the irrigators surveyed who were growing alfalfa on sandy soils may have been superior water managers. In conclusion, net returns for the higher yielding alfalfa crops were over $19.00 per acre in 1977 compared with $-7.90 per acre on heavier soils.

In the southern rainfall region, two major groups of soil associations were delineated as well. The first of these groups consisted of silty and loamy soils that were fairly well drained. Soil associations contained in this group included Egan-Chancellor, Egan-Wentworth-Clarno, and Egan-Wentworth-Viborg. A complete budget for irrigated corn was the only crop budget that could be calculated for this soil association group (see Appendix A).

The second major soil group found in the southern rainfall region represented clayey-loam and alluvial soils with sandy or gravelly substrata. Soil associations contained in this group were Delmont-Enet and Delmont-Graceville-Talmo. Budgets for irrigated corn, alfalfa, and soybeans were derived for this soil association group (see Appendix A).

Like the northern rainfall region, per acre crop yields, total variable costs, total costs, and net returns for corn in 1977 were calculated for each soil type group and the southern rainfall region as a whole (see column 2, Table 4.9). As in the northern region, corn yields were higher on the soils without the gravelly substrata. Irrigated corn yielded 152 bushel per acre on the silty and loamy soils with the less porous base and 135 bushel per acre on the sandy based soil. Corn on sandy based soils in the southern rainfall region yielded higher than in the northern region, probably because of heavier fertilization and more natural precipitation. Per acre net returns in 1977 averaged near $10.00 per acre on the heavier soil. This was $35.00 greater than the negative $25.00 returns on the sandy based ground.

Alfalfa on the sandy based soil yielded 5.9 ton per acre on the average in 1977. The resulting net returns to management, labor and water were near zero. Lack of a sufficient number of respondents growing alfalfa on soils with a denser base prevented a comparison between soil types.

Composite Acre Net Returns for Each Rainfall Region 1970-1977

Following the procedure explained in Chapter III, the irrigated and dryland composite acre net returns to labor, management, and (in the case of irrigation) water were calculated in each region for the years 1970-1977. Those dryland and irrigated net returns and the difference between the two appear in columns 1, 3, and 5 of Tables 4.11 and 4.12. Labor costs per composite acre were then deducted from those net returns in order that net returns to management and (in the case of irrigation) water could be presented (see columns 2, 4, and 6 of Tables 4.11 and 4.12).

Table 4.11: Composite Acre Net Returns
Northern Rainfall Region 1970-1977

	Irrigated		Dryland		Difference	
	Ret to L,M,W	Ret to M&W	Ret to L&M	Ret to M	Ret to L,M,W	Ret to M&W
1970	$ 38.45	$ 32.45	$ -4.75	$ -7.75	$ 43.20	$ 40.20
1971	19.10	12.70	-11.45	-14.65	30.55	27.35
1972	45.20	38.40	3.90	.50	41.30	38.90
1973	142.95	135.55	43.30	39.60	99.65	95.95
1974	202.00	193.80	26.80	22.70	175.20	171.10
1975	117.00	108.60	11.35	7.15	105.65	101.45
1976	128.85	119.85	-38.25	-42.75	167.10	162.60
1977	12.05	2.25	-5.85	-10.75	17.90	13.00
Avg.	$ 88.20	$ 80.45	$ 3.15	$ -.75	$ 85.05	$ 81.30

L = labor

M = management

W = water

Table 4.12: Composite Acre Net Returns
Southern Rainfall Region 1970-1977

	Irrigated		Dryland		Difference	
	Ret to L,M,W	Ret to M&W	Ret to L&M	Ret to M	Ret to L,M,W	Ret to M&W
1970	$ 38.45	$ 33.20	$-14.65	$-17.65	$ 53.10	$ 50.85
1971	18.95	13.35	-11.85	-21.05	30.80	34.40
1972	53.85	47.90	18.00	14.60	35.85	33.30
1973	156.75	150.25	42.20	38.50	114.50	111.75
1974	216.45	209.25	34.10	30.00	182.35	179.25
1975	113.40	106.05	.25	-3.95	113.15	110.00
1976	81.60	73.70	-24.20	-28.70	105.80	102.40
1977	4.75	-3.85	-4.05	-8.95	8.80	5.10
Avg.	$ 85.50	$ 78.75	$ 5.00	$ .35	$ 80.55	$ 78.40

L = labor

M = management

W = water

The composite dryland and irrigated acres used in calculating the net returns contained in Tables 4.11 and 4.12 were determined to contain the following percentages of major crops grown in each rainfall region.

Northern Rainfall Region

Irrigated Composite Acre		Dryland Composite Acre	
Corn	66.9%	Corn	29.0%
Corn Silage	14.4%	Corn Silage	10.0%
Alfalfa	14.5%	Oats	29.2%
Soybeans	4.2%	Flax	7.8%
		Alfalfa	13.4%
		Soybeans	3.3%
		Wheat	4.6%
		Barley	2.7%

Southern Rainfall Region

Irrigated Composite Acre		Dryland Composite Acre	
Corn	71.0%	Corn	42.0%
Corn Silage	4.6%	Corn Silage	8.7%
Alfalfa	7.6%	Alfalfa	9.6%
Soybeans	16.8%	Soybeans	12.7%
		Oats	27.0%

The remaining crops grown in each rainfall region comprised less than one percent of total cropland and were treated as insignificant portions of the composite acres.

Net Returns to Labor, Management, and Water

Composite irrigated acre net returns to labor, management, and water for each rainfall region ranged from $12.05 in 1977 to $202.00 in 1974 in the northern region. For the southern, the range was from a low of $4.75, also in 1977, to $216.45 in 1974 (see column 1 of Tables 4.11 and 4.12).

For dryland farmers, net returns to labor and management reached their peaks in 1973 at $43.30 per composite acre in the northern region and $42.20 in the southern region (see column 3 of Tables 4.11 and 4.12). As could be expected, dryland net returns to labor and management reached their lows in the drought year of 1976 when they were $-44.25 per composite acre in the north and $-30.20 in the southern rainfall region.

The difference between composite irrigated acre net returns to labor, management, and water and dryland net returns to labor and management did not reach its maximum level in 1976 as might be expected during a time of drought. The 1976 differences (shown in column 5 of Tables 4.11 and 4.12) between irrigated and dryland net returns were $167.10 in the northern region and $105.80 per composite acre in the southern one. The maximum difference between irrigated and dryland net returns occurred in 1974 in each region, with that difference being $175.20 in the northern region and $182.35 per composite acre in the neighboring region to the south. The minimum differences between irrigated and dryland composite acre net returns occurred in 1977 when that difference equalled $17.90 per composite acre in the north and $8.80 in the southern rainfall region.

As alluded to previously, the most obvious reason for dryland returns reaching their low point in each region in 1976 was the occurrence of an extreme drought in eastern South Dakota which caused yields of all dryland crops included in the composite acre to be extremely low. Returns to labor, management and water were smallest in 1977, primarily due to the low price of corn. The average annual price of corn for 1977 in South Dakota hovered near $1.80 per bushel. This low price proved to be the major factor that depressed the net returns of the corn intensive composite irrigated acre.

As a result of the pronounced drought that occurred in 1976, great numbers of dryland farmers made the move to irrigation in eastern South Dakota in 1977. But, as noted in the previous paragraph, 1977 was not a particularly good year profit-wise for the irrigators. Since crop prices did not improve much in 1978, that year was not much better. It could be expected that those who became irrigators since 1976 have experienced more financial difficulties than those who were irrigating during the early 1970's. Composite acre net returns to management, labor, and water for irrigated crops peaked in 1973, when they surpassed the $200 mark (see column 1, Tables 4.11 and 4.12). Those large net returns were primarily due to corn prices in South Dakota that topped $3.00 per bushel and soybean prices that reached over the $6.50 per bushel figure.

Dryland composite acre net returns to management and labor in each rainfall region achieved their maximums for the eight year period in 1973, a year earlier than irrigated. Corn, soybean, and small grain prices were excellent in 1973 and 1974. Dryland crop yields were generally higher in 1973 compared to 1974 in both regions as well.

In summary, net returns to labor, management and water averaged $88.20 per composite irrigated acre in the northern region and $85.50 for the southern rainfall region over the eight year period. Average dryland returns to labor and management were $3.15 per composite acre in the north and $5.00 in the south.

It should be noted in column 1 of Tables 4.11 and 4.12 that net returns to labor, management, and water per irrigated composite acre were never negative during the eight year period in either rainfall region. At the same time, dryland composite acre returns to labor and management were negative 50 percent of the time in each rainfall region. The question could be raised concerning how dryland operators losing money half of the time on their crop enterprises stayed in business. One possible explanation was that they have been accepting a return on their investment in land of less than the six percent of market value included as a cost in the crop budgets. By accepting returns of as low as two percent the crop enterprises would have exhibited positive net returns. It is also possible that the cash flow being generated by farmers' livestock enterprises during that period were more than enough to offset the losses incurred in the crop enterprises. Finally, the net returns presented in Tables 4.11 and 4.12 are average figures. Actual net returns of individual dryland farmers would be scattered at intervals both above and below that average. Therefore, it can be concluded that not all dryland farmers lost money on their crops 50 percent of the time and that some of the farmers lost money more than 50 percent of the time. Farmers in that lower part of the profits scale would likely be the ones forced out of business by a drought year like 1976.

Many of the same comments can be made about the irrigators. Some irrigators in the southern rainfall region likely netted less than $5.00 per composite acre in 1977 and others probably fared better. By the same token, a number of irrigators probably netted more than $200.00 in 1974 and some less. At any rate, irrigators have received a more stable and financially sound level of income from their crop enterprises over time than their dryland counterparts. Irrigation has reduced the natural risks involved in crop production and has resulted in an improved borrowing position for the irrigator. In that context it is difficult to place a value on water used for irrigation. In the next section the values for labor and finally management will be deducted from the net returns presented in this section, leaving a residual solely attributable to water.

Net Returns to Management and Water

Dr. Wallace Aanderud of the Economics Department at South Dakota State University provided estimates of the hours of labor normally employed in the production of the crops included in the composite dryland and irrigated acres for each rainfall region. Labor charges were deducted from the returns presented in columns 1 and 3 of Tables 4.11 and 4.12. From the estimates provided by Dr. Aanderud, estimated labor requirements per composite irrigated acre were found to be 4.0 hours in the northern rainfall region and 3.5 hours in the southern region. Dryland composite acre labor requirements were found to equal 2.0 hours in each rainfall region. It was assumed that all of the labor necessary could be hired at the average wage rate being paid to farm labor during the appropriate time period. The wage rates used to calculate labor charges were averages of hourly wage rates paid to farm laborers in South Dakota for the months of April through October (South Dakota Crops and Livestock Reporting Service, 1973, p. 61, 1976, p. 91 and unpublished data, 1979).

The calculated rate ranged from $1.50 per hour in 1970, to $2.05 in 1974, to $2.45 per hour in 1977. The resulting labor charges per composite irrigated acre ranged from $6.00 in 1970 to $9.80 in 1977 in the northern rainfall region. In the southern region, the labor charge per composite irrigated acre was $5.25 in 1970 and equalled $8.60 per composite acre in 1977. Deducting those labor charges from the returns shown in column 1 of Tables 4.11 and 4.12 yielded the composite irrigated acre returns to management and water for each rainfall region listed in column 2 of Tables 4.11 and 4.12. For example, in the northern rainfall region the returns to labor, management, and water per composite irrigated acre in 1970 was $38.45. Deducting the labor charge of $5.25 per composite acre left $33.20 as the return to management and water per composite irrigated acre.

The net returns to management and water in the case of irrigation and the net return to management per dryland composite acre reached their peaks and lows in the same years as the returns to labor, management, and water or labor and management for dryland. For example, net returns to management and water per irrigated composite acre reached a peak of $193.80 in the northern region in 1974; the same year that returns to labor, management and water in that region reached $202.00. The analysis of why net returns per composite acre were greatest in certain years and lowest in other applies regardless of whether or not labor is included in those returns. After labor charges were deducted, dryland returns to management per composite acre went from barely positive to $-3.95 in 1975 in the southern rainfall region. Returns to management and water for 1977 in the southern region also moved from $4.75 per composite acre to $-3.85 when the labor charge was deducted.

In summary, returns to water and management presented in Tables 4.11 and 4.12 ranged from $-3.85 to $209.95 per composite irrigated acre in the southern rainfall region and from $2.25 to $193.80 per composite acre in the northern region. Average returns over the eight year period were $78.75 in the southern region and $80.45 per composite acre in the northern region. Dryland returns to management ranged from $-28.70 to $38.50 per composite acre in the south and from $-42.75 to $39.60 in the northern region. Average dryland returns per composite acre over the eight year period were very close to zero, with the northern region's being slightly positive and the southern's slightly nagative.

Net Returns to Water

The final setp in the process of estimating a value for water in irrigation involved the deduction of a management charge from the difference between returns to management and water per irrigated composite acre and returns to management per dryland composite acre. In terms of the results presented in Tables 4.11 and 4.12, a management charge was deducted from the values (returns to management and water) appearing in column 6 in Tables 4.11 and 4.12 and are presented in Table 4.13.

The management charge for dryland and irrigated composite acres was assumed to be 10 percent of total variable costs. Total variable costs for each crop included in the composite acres for dryland and irrigated ground were calculated for each of the years 1970-1977. Each of these cost figures was multiplied by the relative percentage its associated crop occupied in the composite acre. As an example, the per acre total variable cost of growing irrigated corn inthe northern rainfall region was $118.00 per acre in 1977. That figure was multiplied by .669 (the percentage of the composite irrigated acre consisting of corn) to find the portion of composite irrigated acre total variable costs attributable to corn in 1977. In the same manner, weighted total variable costs of the other crops included in the composite irrigated acre were calculated. By adding those costs together, composite irrigated acre total variable costs were calculated for 1977. The same procedure was then used for all irrigated and dryland crops grown in each rainfall region for the years 1970-1977.

In the northern rainfall region, composite irrigated acre total variable costs ranged from $56.30 in 1970 to $104.00 in 1977. Dryland composite acre total variable costs ranged from $23.50 in 1970 to $43.40 in 1977. The difference between irrigated and dryland costs ranged from $32.80 in 1970 to $60.60 in 1977.

In the southern rainfall region, composite irrigated acre total variable costs ranged from $62.90 i1970 to $116.20 in 1977. Dryland composite acre total variable costs ranged from $26.00 in 1970 to $53.10 in 1977. The calculated difference between irrigated and dryland was $36.90 per composite acre in 1970 and increased to $63.10 in 1977.

The management charges associated with the variable costs above ranged from $3.30 per composite acre in 1970 to $6.00 per composite acre in 1977 in the northern rainfall region. In the southern region, management charges per composite acre ranged from $3.70 in 1970 to $6.30 in 1977. The last step was to deduct these composite acre management charges for each of the years 1970-1977 from the corresponding net returns to management and water for each rainfall region. The results were the values presented in Table 4.13 which represent composite acre net returns to water for the years 1970-1977 in the northern and southern rainfall regions.

Table 4.13: Composite Acre Net Returns to Water by Rainfall Region 1970-1977

Year	Northern Rainfall Region ($)	Southern Rainfall Region ($)
1970	36.90	47.15
1971	23.85	30.80
1972	35.30	29.50
1973	91.55	107.15
1974	166.00	174.25
1975	95.85	104.30
1976	156.70	96.40
1977	7.00	-5.40
8 year average	76.60	73.90

In the northern rainfall region, composite acre net returns to water ranged from a low of $7.00 in 1977 to a high of $166.00 in 1974. The primary reason for 1977 being the year of lowest return to water, was that crop prices were low in 1977. As mentioned in a previous section of this chapter, corn prices averaged near $1.80 per bushel in 1977. In 1974, the value of water reached its peak primarily due to excellent crop prices, with corn reaching $3.00 per bushel and soybeans topping $6.50 per bushel. The eight year average value of water was found to be over $76.00 per composite acre in the northern rainfall region.

The high and low values for water in the southern region were found in the same years as in the northern region. Low crop prices in 1977 were the major reason for water's value equalling $-5.40 per composite acre. The high value of over $174.00 achieved in 1974 was due again to favorable crop prices. The eight year average value for water in the southern region was found to be near $74.00 per composite acre.

It is interesting to note that the value of water was quite high in each region during the drought year of 1976. The value of water per composite acre neared $96.00 in the southern rainfall region and exceeded $156.00 in the northern region in 1976. The large differential between the two regions can be partially explained by the fact that the drought was more pronounced in the northern region than in the southern one. The difference in yields between dryland and irrigated crops was larger in the northern region than in the southern one, accounting for greater returns to water in the northern region.

It is important to note that the returns to water above are average returns. Individual irrigators had lower and higher returns to water than those presented. Policy makers tasked with establishing an equitable system of water pricing which would have to consider a range of returns rather than just the average over all irrigators in a region.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The occurrence of periodic drought in eastern South Dakota historically has had adverse effects on the level of production of agricultural crops. Undependable and untimely levels of precipitation have depressed not only farm incomes, but the incomes of businesses that depend on agriculture for their livelihoods. Some farmers in eastern South Dakota have attempted to stabilize their incomes by the application of water through irrigation systems. The resulting increase in the demand for finite supplies of water has given rise to concern among those interested in the allocation of water efficiently among competing uses. It has thus become essential that values for water in alternative uses be estimated.

Summary and Implications

The primary objective of this study was to estimate a value for water used in irrigated crop production in the Big Sioux and Vermillion River Basins of eastern South Dakota. The attainment of that objective entailed the development of irrigated and dryland crop production budgets within those river basins. Surveys of irrigators in two rainfall regions contained in the basins yielded the information necessary to derive irrigated crop production budgets, while dryland budgets were adapted from secondary sources. Deflation of the 1977 costs contained in the budgets resulted in historical dryland and irrigated crop production budgets for the period 1970-1977. Those budgets were used to calculate net returns per acre for dryland and irrigated crops for that same period. Those net returns were adjusted to reflect the proportion of total cropland occupied by each major crop. The resulting net returns per irrigated and dryland composite acre represented returns to labor and management in the case of dryland crop production and returns to labor, management, and water in irrigated crop production. Labor and management charges were then deducted from the net returns, yielding an estimate for the average value of water used for irrigation.

Estimating an average value of water as a resource used in the production of agricultural commodities involved the application of Euler's Theorem and the theory of residual imputation. Those two interrelated segments of microeconomic theory served as the basis upon which the resulting estimates of water's value in irrigation were made.

The 1977 irrigated crop production budgets derived from survey data gathered from irrigators in each river basin were presented in tabular form with comparable dryland budgets adapted from secondary sources. Based on average crop production budgets for each rainfall region, irrigated corn compared quite favorably with its dryland counterpart. The average yield of irrigated corn equalled 129 bushels per acre in the northern rainfall region and 145 bushels per acre in the southern region. Dryland yields were found to be 55 bushels per acre in the northern region and 75 bushels per acre in the southern rainfall region. The price farmers had to receive in order to cover all costs of producing corn in 1977 was $2.25 per bushel for dryland corn and $1.80 for irrigated in the northern region. In the southern rainfall region, the break-even price for irrigated and dryland corn crops were $1.85 per bushel.

The break-even prices calculated for irrigated and dryland corn silage indicated that dryland was the more favorable alternative in 1977. In the northern rainfall region, break-even price for irrigated corn silage was calculated to be $11.10 per ton while dryland's was $8.90 per ton. In the southern region, $14.50 per ton was the price necessary for irrigated corn silage producers to break-even and the dryland break-even price was $10.15 per ton. The major advantage of producing irrigated corn silage, however, was that it yielded more tonnage per acre than dryland, allowing producers to devote less acres to the production of feed necessary for their cattle feeding operations. Irrigated corn silage yielded 8.1 more tons per acre than dryland in the northern region and 5.0 more in the southern rainfall region.

The break-even prices calculated for irrigated alfalfa in 1977 were $38.00 per ton in the southern rainfall region and $35.30 per ton in the north. Comparable prices calculated for dryland alfalfa were $29.95 per ton in the south and $31.95 in the northern rainfall region. As was the case with corn silage, the major advantage of irrigating alfalfa was that fewer acres needed to be devoted to the production of hay necessary for feeding operations. Irrigated alfalfa grown in the southern region yielded 5.9 tons per acre compared to 3.5 tons on dryland. In the northern rainfall region, 4.6 tons per acre were found to be the average yield for irrigated alfalfa, while the dryland average yield was 2.5 tons per acre.

Irrigated soybeans proved to be a profitable alternative in the northern region with a break-even price of only $4.15 per bushel compared to $5.10 for dryland beans. This was primarily because irrigated soybeans yielded an average of 38 bushels per acre while dryland soybeans managed 19 bushels per acre. In the southern rainfall region, irrigated soybean yields averaged 46 bushels per acre while dryland averaged 25 bushels per acre. Break-even prices for dryland and irrigated beans were virtually equal at near $4.40 per bushel.

The primary results of this study indicated that irrigators' net returns to labor, management, and water have always been positive and at all times greater than similar returns to producers of dryland crops. In the northern rainfall region from 1970 to 1977 estimated net returns to labor, management, and water ranged from $12.05 to $202.00 per composite irrigated acre. Dryland returns to labor and management during that same period in the northern region ranged from $-38.25 to $43.30 per composite acre.

In the southern rainfall region, estimated net returns to labor, management, and water from 1970-1977 ranged from $4.75 to $216.45 per composite irrigated acre, while dryland returns to labor and management reached a low of $-4.05 and peaked at $42.20 per composite acre. The eight year average differences between irrigated returns to labor, management and water and dryland returns to labor and management were $85.05 per composite acre in the northern rainfall region and $80.55 per composite acre in the southern region.

By deducting labor charges from the annual returns discussed in the preceeding paragraph, returns to management and water per composite irrigated acre and returns to management per composite dryland acre were determined. Those returns to management and water ranged from $2.25 to $193.80 per composite irrigated acre in the northern rainfall region and from $-3.85 to $209.25 per composite irrigated acre in the southern region. Dryland returns to management ranged from $-42.75 to $39.60 per composite acre in the north and from $-28.70 to $38.50.

Estimates of values for water used for irrigation were determined by deducting management charges from the differences between composite irrigated acre returns to management and water and dryland composite acre returns to management. The returns to water ranged from an average of $7.00 to $166.00 per composite irrigated acre in the northern rainfall region and from $-5.40 to $174.25 per composite irrigated acre in the southern rainfall region. The average return to water per composite irrigated acre over the years 1970-1977 was approximately $77.00 in the northern region and $74.00 in the southern rainfall region. Note that these were average returns to water and that a range of returns to water existed within each area.

Crop production budgets presented in Chapter IV and Appendix A could serve as useful management tools for irrigators and dryland farmers. Irrigators could use cost figures contained in the irrigated enterprise budgets in comparison with their own costs to see where they stand in relation to costs of the average irrigator. Comparisons of that type would allow the manager to see the strong and weak points of his own operation. Dryland farmers could use the dryland budgets for the same purpose. Prospective irrigators could use the budgets as indicators of what costs they should expect to incur should they make the decision to invest in an irrigation system.

Limitations

Limitations of Theory

The major limitation to the application of Euler's Theorem and residual imputation in the process of estimating a residual value for labor, management, or water in irrigated crop production is that "the product or reward to one factor of production cannot be established accurately except as the rewards for other factors are accurately reflected" (Heady, 1952, p. 403). The costs reflected in the irrigated crop production budgets presented in Chapter IV and Appendix A are actual costs incurred by irrigators. In that regard, they should be quite accurate estimates of each input's value in the production process. Thus, the problem of accurately reflecting each factor's value is diminished, although not eliminated.

Limitations of Method

The use of indexes of prices paid by farmers in deflating the 1977 crop production costs to obtain historical net returns of dryland and irrigated crops caused some problems. The reliability and usefulness of that type of index is questionable. However, lack of a better alternative led to the use of the indexes.

The use of budgets which were derived by averaging data over heterogeneous geographic areas also created some problems. In theory, averaging should only be done if the observational units are perfectly homogeneous. In reality, no two farming enterprises can be completely homogeneous. Although an attempt was made to remedy this problem by breaking all survey respondents down into soil type categories, that breakdown was not a significant factor in the estimation of the value for water in irrigation.

The calculation of depreciation charges for farm machinery entailed the assumption that all farm equipment had salvage values equal to 10 percent of their original costs. In recent years, however, certain types of farm equipment (especially tractors) have appreciated in value rather than depreciated. That appreciation in value would probably increase the salvage value of the equipment to a higher level than 10 percent of original cost. Increasing the salvage value would, in turn, lower the fixed costs per composite acre, making a crop enterprise look more profitable than was shown in the enterprise budgets in Chapter 4. Closely aligned with depreciation are allowances for investment credit which were not used in this study. Future studies may include such variables.

Recommendations for Further Research

This study has provided much of the essential base data necessary for extended research. Using the irrigated crop production budgets presented in Chapter IV, various water pricing policy alternatives could be evaluated according to their impacts on net income from irrigated crop production.

Irrigated crop production budgets could also be used as part of the data base necessary to estimate potential regional economic impacts of possible irrigation development. Community development planners need to be supplied with estimates of the expected levels of incomes of businesses that could be generated by development of irrigation. The comparison of those expected benefits with the associated costs would be of value in decisions concerning whether or not to support further irrigation development.

Research into the impacts of changing costs of factors of production such as electricity, fuel, fertilizer, etc., on the profitability of irrigation is also necessary. Potential irrigators need the results of this type of research in order to make financially sound choices concerning possible long-run investment of capital for an irrigation system(s).

Due to annual fluctuations in the amounts of rainfall received during the growing season, the amount of water applied through irrigation varies accordingly. Therefore, it is necessary to look more closely at the amount of water being applied over time. That data could then be extended to determine net returns to water per acre-foot or acre-inch applied over time.

There is a definite need for a study which would examine and compare values of water in alternative uses. Policy makers would then have a solid basis for allocating scarce water supplies among such competing ends as domestic, industrial, commercial, agricultural, and other alternative uses.

The final recommendation for further research in this area is that of the need to periodically update and revise the budgets presented in this study. Because methods and costs of irrigation, soil tillage, fertilization, and chemical application change so frequently, budgets can quickly become outdated. Revisions should be accomplished not only through the use of price and productivity indexes, but also through the use of direct personal interviews with farmers incurring the costs.

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APPENDIX A

Table A.1: Enterprise Budget for Irrigated Corn on Loamy or Silty Soil in the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 8.50-13.60	$ 11.55
Fertilizer	20.00-59.00	42.80
Chemicals	7.60-19.90	13.25
Crop Ins.	0-5.55	1.60
Mach. Rep.	1.49-19.00	7.00
Fuel & Lube	2.35-13.90	4.25
Drying	0-23.10	10.90
Storage	0-7.00	.70
Overhead	3.60-7.20	5.60
Subtotal	$ ----	$ 97.65
System Power	10.65-19.50	14.45
System Repair	0-.75	.15
Custom Hire	0-13.00	5.50
Subtotal	$ ----	$ 20.10
Int. on Op. Cap.	3.40-6.80	5.30
Total Var. Costs	$ 78.70-158.10	$123.05
Fixed Costs		
Int. on Invest.	10.85-29.15	19.95
Deprec., Tax, Ins.	20.10-48.65	36.60
Land Charge	----	60.00
Total Fixed Costs	$ 90.95-135.00	$116.55
Total Cost	$200.95-284.65	$239.60
Yield	113-155 bu.	135 bu.
Break-even Price	$ 1.50-2.20	$ 1.75

Table A.2: Enterprise Budget for Irrigated Corn on Sand or Gravel Based Silty or Loamy Soil in the Northern Rainfall Region for 1977

Input	Costs Per Acre Range	Average
Variable Costs		
Seed	$ 8.70-15.00	$ 11.45
Fertilizer	9.65-42.75	31.60
Chemicals	7.90-19.30	14.85
Crop Ins.	0-12.00	2.00
Mach. Rep.	3.60-17.05	7.25
Fuel & Lube	1.65-5.70	4.05
Drying	3.40-19.75	11.60
Storage	0-13.75	2.30
Overhead	2.60-6.20	5.00
Subtotal	$ ---	$ 90.10
System Power	5.75-18.00	10.80
System Repair	0-1.50	.25
Custom Hire	0-21.00	3.15
Subtotal	$ ---	$ 14.20
Int. on Op. Cap.	2.45-5.85	4.70
Total Var. Costs	$ 57.40-135.80	$110.20
Fixed Costs		
Int. on Invest.	$ 12.20-18.35	$ 15.65
Deprec., Tax, Ins.	16.50-39.50	29.15
Land Charge	---	60.00
Total Fixed Costs	$100.95-109.25	$104.80
Total Cost	$166.65-244.35	$215.00
Yield	85-141 bu.	118 bu.
Break-even Price	$ 1.50-2.15	$ 1.80

Table A.3: Enterprise Budget for Irrigated Corn on Loamy or Silty Soil in the Southern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 10.00-16.65	$ 14.20
Fertilizer	43.25-65.00	54.90
Chemicals	5.70-16.75	12.05
Crop Ins.	0-25.00	8.45
Mach. Rep.	1.90-12.05	6.15
Fuel & Lube	3.00-5.40	4.20
Drying	0-10.10	4.70
Storage	---	---
Overhead	4.80-7.00	6.05
Subtotal	$ ---	$110.70
System Power	5.50-16.40	12.55
System Repair	0-1.60	.40
Custom Hire	0-10.00	2.80
Subtotal	$ ---	$ 15.75
Int. on Op. Cap.	4.55-6.60	5.70
Total Var. Costs	$105.30-153.85	$132.15
Fixed Costs		
Int. on Invest.	$ 14.90-37.75	$ 23.30
Deprec., Tax, Ins.	31.95-62.65	40.80
Land Charge	---	72.00
Total Fixed Costs	$115.70-172.40	$136.10
Total Cost	$224.20-311.35	$268.25
Yield	135-186 bu.	152 bu.
Break-even Price	$ 1.20-2.20	$ 1.75

Table A.4: Enterprise Budget for Irrigated Corn on Sand or Gravel Based Clayey-Loam or Alluvial Soil in the Southern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 13.00-18.00	$ 14.95
Fertilizer	27.50-80.00	48.90
Chemicals	8.75-18.00	12.35
Crop Ins.	6.40-15.00	8.65
Mach. Rep.	1.15-13.35	7.05
Fuel & Lube	3.75-6.85	4.80
Drying	0-13.50	5.90
Storage	---	---
Overhead	4.65-8.10	6.10
Subtotal	$ ---	$108.70
System Power	8.85-25.00	15.15
System Repair	0-3.20	.90
Custom Hire	0-8.00	3.40
Subtotal	$ ---	$ 19.45
Int. on Op. Cap.	4.40-7.65	5.85
Total Var. Costs	$101.75-177.70	$134.00
Fixed Costs		
Int. on Invest.	$ 20.30-29.75	$ 25.10
Deprec., Tax, Ins.	38.70-46.60	41.00
Land Charge	---	72.00
Total Fixed Costs	$131.75-144.30	$138.10
Total Cost	$236.90-322.00	$272.10
Yield	110-150 bu.	135 bu.
Break-even Price	$ 1.80-2.50	$ 2.00

Table A.5: Enterprise Budget for Irrigated Alfalfa on Silty or Loamy Soil in the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 3.00-6.65	$ 4.50
Fertilizer	0-30.00	15.95
Chemicals	----	----
Crop Ins.	----	----
Mach. Rep.	1.15-19.00	8.55
Fuel & Lube	1.50-5.85	3.40
Drying	----	----
Storage	----	----
Overhead	1.65-3.60	2.70
Subtotal	$ ----	$ 35.10
System Power	3.75-19.50	11.95
System Repair	0-1.35	.55
Custom Hire	0-30.00	9.60
Subtotal	$ ----	$ 22.10
Int. on Op. Cap.	1.60-3.40	2.55
Total Var. Costs	$ 36.60-78.85	$ 59.75
Fixed Costs		
Int. on Invest.	$ 6.65-18.70	$ 12.50
Deprec., Tax, Ins.	24.15-46.50	31.05
Land Charge	----	60.00
Total Fixed Costs	$ 90.80-125.20	$103.55
Total Cost	$137.75-187.05	$163.30
Yield	3.3-5.5 ton	4.2 ton
Break-even Price	$ 33.60-53.30	$ 38.90

Table A.6: Enterprise Budget for Irrigated Alfalfa on Sand or Gravel Based Loamy or Silty Soil in the Northern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 3.35-5.95	$ 4.55
Fertilizer	10.00-26.00	17.35
Chemicals	----	----
Crop Ins.	----	----
Mach. Rep.	3.60-17.05	8.00
Fuel & Lube	1.95-4.20	3.45
Drying	----	----
Storage	----	----
Overhead	1.35-3.05	2.30
Subtotal	$ ----	$ 35.65
System Power	5.75-18.00	11.45
System Repair	0-1.50	.40
Custom Hire	0-4.80	1.20
Subtotal	$ ----	$ 13.05
Int. on Op. Cap.	1.25-2.90	2.20
Total Var. Costs	$ 29.65-67.15	$ 50.90
Fixed Costs		
Int. on Invest.	$ 11.90-20.50	$ 15.95
Deprec., Tax, Ins.	29.35-46.00	35.35
Land Charge	----	60.00
Total Fixed Costs	$102.15-126.50	$111.30
Total Cost	$141.10-192.50	$162.20
Yield	4.0-6.5 ton	4.9 ton
Break-even Price	$ 26.05-48.15	$ 33.10

Table A.7: Enterprise Budget for Irrigated Alfalfa on Sand or Gravel Based Clayey-Loam or Alluvial Soil in the Southern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 2.80-4.00	$ 3.65
Fertilizer	15.60-34.00	25.10
Chemicals	---	---
Crop Ins.	---	---
Mach. Rep.	6.05-8.95	7.35
Fuel & Lube	3.15-8.00	5.35
Drying	---	---
Storage	---	---
Overhead	2.80-3.35	3.00
Subtotal	$ ---	$ 44.45
System Power	3.35-25.00	13.00
System Repair	0-1.25	.25
Custom Hire	0-24.00	5.15
Subtotal	$ ---	$ 18.40
Int. on Op. Cap.	2.65-3.15	2.85
Total Var. Costs	$ 61.55-73.00	$ 65.70
Fixed Costs		
Int. on Invest.	$ 21.35-35.75	$ 29.55
Deprec., Tax, Ins.	44.55-59.05	51.05
Land Charge	---	72.00
Total Fixed Costs	$137.85-166.80	$152.60
Total Cost	$199.45-233.35	$218.30
Yield	5.5-6.9 ton	5.9 ton
Break-even Price	$ 28.50-50.90	$ 37.00

Table A.8: Enterprise Budget for Irrigated Soybeans on Sand or Gravel Based Clayey-Loam or Alluvial Soil in the Southern Rainfall Region for 1977

Input	Costs Per Acre	
	Range	Average
Variable Costs		
Seed	$ 8.75-11.50	$ 10.05
Fertilizer	0-19.40	4.85
Chemicals	4.30-10.00	7.60
Crop Ins.	0-15.00	5.65
Mach. Rep.	1.15-13.35	6.70
Fuel & Lube	2.35-5.00	3.65
Drying	---	---
Storage	---	---
Overhead	2.15-5.70	3.25
Subtotal	$ ---	$ 41.75
System Power	6.75-17.00	10.25
System Repair	0-3.22	1.10
Custom Hire	0-10.00	5.00
Subtotal	$ ---	$ 16.35
Int. on Op. Cap.	2.00-2.65	2.40
Total Var. Costs	$ 46.75-61.30	$ 60.50
Fixed Costs		
Int. on Invest.	$ 13.10-21.70	$ 16.40
Deprec., Tax, Ins.	22.65-36.75	32.35
Land Charge	---	72.00
Total Fixed Costs	$108.75-127.25	$120.75
Total Cost	$155.50-188.35	$181.25
Yield	43-60 bu.	50 bu.
Break-even Price	$ 3.05-4.40	$ 3.65

A P P E N D I X B

Form B.1: Enterprise Budgeting Form

Budget Description — Crop ______ Rainfall Region ______ Soil Type ______

A. Yield per Acre ______

B. Variable Costs per Acre

Operation	Width	Grnd. Sp.	Ac./Hr.	Fuel Price	Times Over	Field Effic.	1. Fuel Cost per Acre

2. System Power ______
3. Oil and Grease ______
4. Repair on Machinery ______
5. Repair on System ______
6. Custom Machine Hire ______
7. Custom Labor Hire ______
8. Seed ______
9. Fertilizer ______
10. Herbicide ______
11. Insecticide ______
12. Crop Insurance ______
13. Drying ______
14. Storage ______
15. Overhead ______
16. Int. on Op. Cap. ______

17. Total Variable Costs ______

C. Fixed Costs per Acre

1. Depreciation on Storage Facilities__________
2. Depreciation on Equipment__________
3. Depreciation on System__________
4. Interest on Land__________
5. Interest on System__________
6. Interest on Equipment & Storag
7. Insurance on Farm__________
8. Insurance on System__________
9. Personal Property and Real Estate Taxes__________
10. Total Fixed Cost__________
11. Total Variable Cost__________
12. Total Cost__________
13. Breakeven Price__________

Form B.2: Questionnaire form used for personal interviews with irrigators.

1. Dryland and Irrigated Crop Rotations - 1977

	Acres Dryland	Acres Irrigated	Applications per year	Water Applied per Application
Corn				
Corn Silage				
Alfalfa				
Soybeans				
Oats				
Barley				
Flax				
Wheat				
Other (specify below)				

2. Irrigated Crop Yields - 1977

CROP					
1977 YIELD					

3. Irrigation System Specifications and Costs

Well	Units	Per Unit Cost	Total Cost
1. Test Holes			
2. Drilling Well			
3. Casing			
4. Screen (galvanized or stainless steel)			
5. Gravel Pack			
6. Test pumping and development			
		Total	

Pump (electric)	Units	Per Unit Cost	Total Cost
1. Pump w/ bowls and installation			
2. Motor			
3. Electric panel & controls			
		Total	

Pump (diesel)	Units	Per Unit Cost	Total Cost
1. Pump w/ bowls and installation			
2. Power unit			
3. Gearhead			
4. Fuel lines & tanks			
		Total	

System Itself	Units	Per Unit Cost	Total Cost
1. Machine			
2. Pipe			
3. Electrical Control Cable			
4. Pressure in System			
		Total	

Permit Fee and Analysis

4. Storage and Drying - Irrigated crops 1977

CROP	Where Stored	Amount Stored	Length of Time	Storage Cost	Did you dry it?	Drying Cost
Corn						
Corn Silage						
Alfalfa						
Soybeans						
Other (specify below						

5. Storage Capacity and Facilities - used for irrigated crops 1977

Type of Facility	Capacity	Crop Stored in 1977	New Cost

6. Did you feed any irrigated crops to livestock? If yes, how much?

7. General characteristics and size of livestock enterprises.

8. What effect (if any) has irrigation had on your livestock enterprises?

9. Seed Cost - irrigated crops 1977

CROP	Planting Rate/A.	Cost per Unit of Seed	Cost per acre
Corn			
Corn Silage			
Alfalfa			
Soybeans			
Other (specify below)			

10. Fertilizer Cost - irrigated crops 1977

CROP	Type Used (LQ,BG,BK)	Components #N #Ph #Po/CWT	Rate of Application	Price $/ton	Cost per acre
Corn					
Corn Silage					
Alfalfa					
Soybeans					
Other (specify below)					

11. Herbicide and Insecticide - irrigated crops 1977

Herbicide

CROP	Types Applied	App. Rate per Acre	Cost per Unit	Total Cost	Cost per Acre
Corn					
Corn Silage					
Soybeans					
Other					

Insecticide

CROP	Types Applied	App. Rate per Acre	Cost per Unit	Total Cost	Cost per Acre
Corn					
Corn Silage					
Soybeans					
Other					

12. Crop Insurance - irrigated crops 1977

CROP	Source	Acres Insured	Rate per Acre
Corn			
Corn Silage			
Soybeans			
Other			

13. Custom Hire (Labor or Machine) - irrigated crops 1977

A. Did you hire labor ________, machine________?

B. For what purpose?

C. At what cost?

14. Fuel, Oil, or other Lubricants - irrigated crops 1977

A. Gasoline ________ ¢/gal.

B. Diesel fuel ________ ¢/gal.

C. What was your cost in 1977 for oil and other lubricants?

D. Fuel or electrical cost of operating the irrigation system.

E. Lubrication cost for the irrigation system.

15. Repair Costs - all crops 1977

A. General Repair Costs

B. Repair Costs for Irrigation System

Fuel Consumption by Implement and Field Operation - irrigated crops 1977

Field Oper.	Width of Imp.	New Cost of Imp.	Model of Tractor	Gear used &/or Ground Speed	New Cost of Tractor	TIMES OVER BY CROP				
						Corn	C.S.	Alf.	Soyb.	Other

16. Interest -1977

A. Operating Loans Interest rate ______%

B. Intermediate Loans Interest rate ______%

C. Long Term Loans Interest rate ______%

17. Taxes - 1977

A. Personal Property Tax

B. Real Estate Tax

18. Insurance on Farm - 1977

Type Carried	Cost

Do you carry additional insurance on your irrigation system?

If yes, at what cost?

19. Family Labor - 1977

	Descrition of duties and time spent
Wife	
Children	